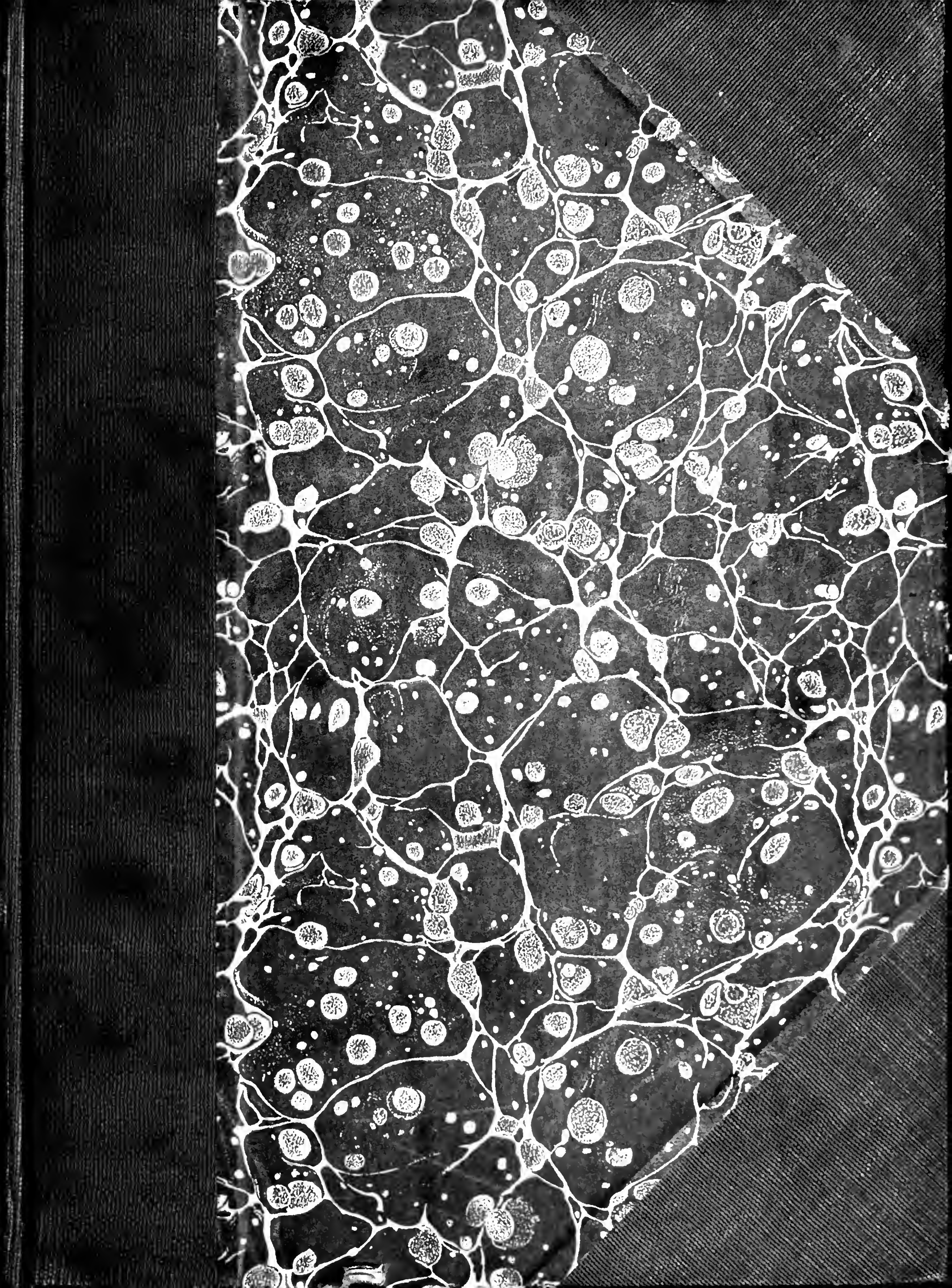


Railway and Locomotive Engineering

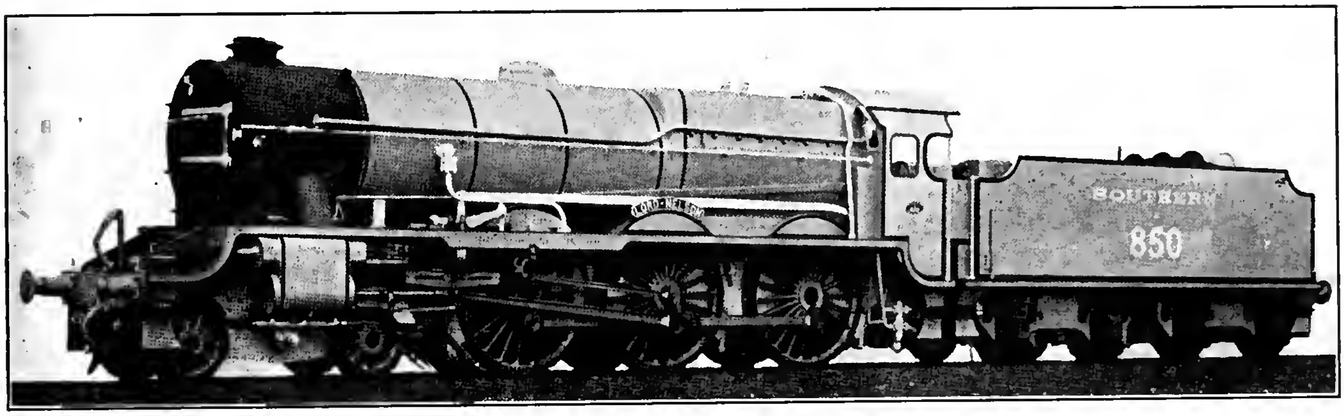
A Practical Journal of Motive Power, Rolling Stock and Appliances

Vol. XL | 136 Liberty Street, New York, January, 1927 | No. 1

A Four-Cylinder Simple Express Passenger Locomotive

Distinctive Features of Design are Incorporated in 4-6-0 Type on the Southern Railway of England

There has been placed in service on the Southern Railway of England a new 4-6-0 type four-cylinder simple express passenger locomotive in which has been embodied some unusual features in design. It was built at the railway company's shops at Eastleigh and was designed by Mr. R. E. L. Maunsell, chief mechanical engineer of the road, in order to meet the increasing weight of fast passenger trains.



Four-Cylinder Simple 4-6-0 Type Locomotive on the Southern Railway of England

It has been estimated that the engine is capable of handling trains of 500 tons weight at speed of 55 miles per hour. It has been named the "Lord Nelson" and is the first of a series of engines to be called the "Nelson" class which will be used to haul trains of the class referred to. It is the most powerful passenger engine in Great Britain, the tractive effort at 85 per cent of the boiler pressure 220 lb. per sq. in. being 33,500 lb.

In this simple four-cylinder superheated steam locomotive the cylinders are arranged two inside and two outside the frames. The inside cylinders are placed slightly in advance of the outside ones, and are formed in one casting with their piston valve steam chests above them. These cylinders drive the crank axle of the foremost pair of coupled wheels, and steam distribution to them is effected by separate inside Walschaerts valve motions actuated by single eccentrics. The outside cylinders are separate castings integral with piston valve steam chests, and these drive the middle pair of coupled wheels, steam distribution in this case being performed by outside Walschaerts gearing having the usual arrangement of coupled cranks.

An interesting feature of the design is that there are eight separate impulses per revolution of the wheels, this resulting from the special disposition of the crank pins, by means of which the individual exhausts from both ends of all cylinders occur separately instead of the usual arrangement of synchronised exhausts giving four beats per revolution of the wheel in the usual four-cylinder engines having quartered cranks and gives a more uniform turning torque and more regular firebox draught. Two years ago Mr. Maunsell experimented with this arrangement of cylinders and cranks by altering one of the four-cylinder engines built to the design of the late Mr. Dugald Drummond, which had the four cylinders, two inside and two outside the frames, driving on two axles with the cranks quartered and having the usual four impulses per revolution. The alteration made by Mr. Maunsell was to turn the cranks of the inside engine through 45 degrees and re-balance the wheels to suit. The improvement secured by this change was so remarkable that it was decided to embody the arrangement in the new engines to be henceforth known as the "Nelson" class.

The revolving and reciprocating parts have been made as light as possible by the use of high tensile steel, and reflects in the lightness of the balance weights in the wheels.

The boiler is of large proportions and is of the Belpaire type with its center line 9 ft. 1 in. above the rail level. The firebox water space stays are made of steel in the fire area with nuts on the fire side and ordinary riveted copper stays elsewhere. The tubes are of moderate length, there being 173 small tubes 2 in. in diameter and 27 large tubes

5¼ in. in diameter. The boiler pressure employed is 200 lb. per square in.

The superheater header is of the "Maunsell" type with air relief valves. The "Ross" type of safety valves are mounted on the firebox, and the fire door is of the sliding type. Other fittings include a soot blower, exhaust injector, and a four feed sight lubricator with separate condensors for the cylinders and valve chests.

The cab is commodious with the fittings conveniently arranged.

The four-wheeled leading truck is of substantial construction with side control springs arranged for adjustment and removal from the outside of the frame, while side steadying bearings to the main frame are provided.

The tender is of the eight-wheel double truck pattern and has a capacity for 6,000 gallons of water and 6 ton of coal. Three steel reservoirs are mounted abreast at the rear end of the tender, these providing enhanced brake power for the wheels of the tender. The barrels are connected directly to the top of the vacuum brake cylinders by piping. When fully loaded the tender weighs 127,000 lbs. making a total for locomotive and tender in working order 314,000 lbs.

The engine has been constructed to haul trains of 500 tons at an average speed of 55 miles per hour, the heaviest trains on the Southern Railway at the present time being from 425 to 450 tons. The overall dimensions of the engine are such as to enable it to run on any main line of the Southern system.

When other engines of the "Nelson" class are built they will be named after the following sea kings: "Lord St. Vincent," "Lord Howe," "Lord Rodney," "Lord Hood," "Lord Hawke," "Howard of Effingham," "Sir Francis Drake," "Sir Walter Raleigh," "Sir Richard Greenville," "Martin Frobisher."

On its initial run last fall and while handling the Atlantic Coast Express between Waterloo and Salisbury, returning on the corresponding up train due to leave Salisbury at 2:26 p.m. Leaving Salisbury ten minutes late, the train arrived at Waterloo only two minutes behind time. The sixty-nine miles from Grately to Clapham Junction were covered in sixty minutes. Andover was passed at 74 miles per hour and Woking at 80 miles per hour. Between Basingstoke and Hampton Court Junction the average speed was 70 miles per hour.

The following are the principal dimensions and other particulars in regard to the locomotive:

Cylinders (four), diam	16½ in.
Cylinders, piston stroke	26 in.
Driving wheels, diam	6 ft. 7 in.
Truck wheels, diam	3 ft. 1 in.
Wheelbase, rigid	15 ft.
Wheelbase, bogie	7 ft. 6 in.
Wheelbase, engine, total	29 ft. 6 in.
Boiler—	
Height of center from rail	9 ft. 2 in.
Diameter inside at front	5 ft. 6⅛ in.
Diameter outside at firebox	5 ft. 9 in.
Length of barrel	13 ft. 9 in.
Length between tube plates	14 ft. 2 in.
Firebox, width	4 ft. 0½ in.
Firebox length, inside	10 ft. 6 in.
Heating surface—	
Firebox	194 sq. ft.
Small tubes	1,282 sq. ft.
Large tubes	513 sq. ft
Total	1,989 sq. ft.
Superheater surface	376 sq. ft.
Combined surface	2,365 sq. ft.
Grate area	33 sq. ft.
Boiler pressure	220 lb. per sq. in.
Tractive effort, at 85 per cent boiler pressure	63,500 lb.
Adhesive factor, at 85 per cent boiler pressure	4.1
ESTIMATED DATA	
Rated tractive force at 85 per cent of boiler pressure	33,500 lb.
Weight of drivers ÷ tractive force	4.14
Engine weight ÷ combined heating surface	79.0
Rated tractive force ÷ combined heating surface	14.17
R.T.F. × drivers, diam. : combined heating surface	1,120
Combined heating surface ÷ grate area	71.7
Firebox heating surface per cent of combined heating surface	8.20
Firebox surface÷grate area	5.88
Superheater surface per cent of combined heating surface	15.9

The 4-6-0 Type Locomotive in the U. S.

By ARTHUR CURRAN

Comment on the 4-6-0 type as used in England in *Railway and Locomotive Engineering* issues of March and June, 1926, suggests that, before leaving the subject, a few words might be said about this wheel arrangement as it is employed in America. The ten-wheeler is still of sufficient importance to warrant notice, as it is doing most of the passenger work below the rank of the fastest trains, and because it is likely to remain in that service for some years to come. The heavy local expresses to suburbs and seaside resorts represent some pretty stiff work for a locomotive of any kind, as will be shown presently.

Elsewhere it has been explained that, due to the demand for rapid acceleration and a certain smartness on runs involving numerous stops, the driving wheel diameter on modern or modernized 4-6-0 engines in the United States is necessarily kept at a moderate figure. Notwithstanding this, such engines are capable of a very fair sustained speed when circumstances permit the use of their full capacity. As an extreme case, I may mention that I have seen a rather old 4-6-0 hauling a heavy suburban express at fully 65 m.p.h. While I do not claim that this engine could do this under adverse conditions, I am certain that, with a dry rail and moderate temperature, the job could be repeated very easily. I admit that the engine was being "flogged"or "thrashed," as the English say; this being evident by the very heavy exhausts. The fact, however, that the boiler could make steam fast enough to stand this racket, with the reverse lever "down in the corner," is proof enough that the design has merits.

On another road, a similar class is used on all through trains! For about six months I watched this road rather closely, meeting everybody from the S. M. P. down to the car "knockers." All spoke with respect of this class. But, of course, it is a small road.

It was to get an engine that would handle heavy local expresses without "thrashing" that prompted the Pennsylvania Railroad to build the Class G-5-s at Altoona in 1923. As these engines were described at the time in the railway press, it is necessary only to remark that their cylinders are 24 x 28 inches, drivers 68 inches in diameter, and weight, exclusive of tender, 237,000 lbs. Tractive force 41,330 lbs.

It is of interest that much of the important work of this class has been done on the Long Island Railroad. An idea of this work may be gathered from the make up of Train 12, Amagansett Express, which embraces five Pullmans and five coaches; ten cars in all. As steel equipment is used, it will be seen very readily that this train approximates a trunk-line outfit.

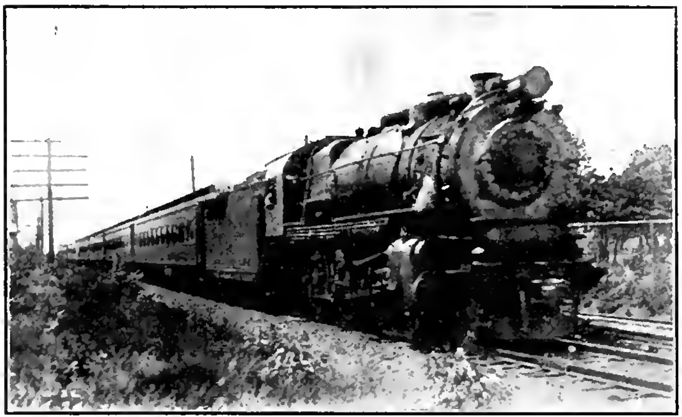
The division over which this train is operated requires some skillful running, as there are numerous curves and grade-crossings, and automobilists who have no conception of railway speeds or the hazards involved in the indulgence of "monkey-shines." Disrespect for crossing-watchmen is considered "smart" by these morons, and the worries of enginemen are thereby increased. However, the train is nicely handled, and for this result the G-5 engines are largely responsible.

The accompanying photograph shows engine No. 24 of this class with the ten-car train, as above described.

Other work done by this class includes the handling of twelve steel coaches at 60 m.p.h., and the long run of the "Sunrise Special"; the latter consisting of Pullmans only. For this run, engine No. 21 has an extra-large tender, as there are no track-tanks on the road.

At this point it may be pertinent to remark that the improvements made on the L. I. R. R. during the past twenty years or so constitute one of the most interesting chapters in the history of American railroading,

There are some exceedingly nice 4-6-0 engines on the Baltimore & Ohio Railroad, though these necessarily represent a modernization policy. Of these, Class B-18A, consisting of 30 engines, is one of the most interesting. These engines were built in 1901—presumably by the Baldwin Locomotive Works — and have 21 x 28 inch cylinders, 70 inch drivers, and weight, exclusive of tender, 173,400 lbs. Their working pressure is 200 lbs. per square inch, and tractive power 30,000 lbs. They are fitted with piston valves, outside steam-pipes and superheaters, and the various improvements made upon them have been carried out in such a manner as to produce a very "clean" design. This is noticeable in the straight, unbroken running-boards; the neat arrangement of piping, and the convenient and well-proportioned cab.


4-6-0 Type Locomotive Hauling Train on Long Island Railroad

One of these engines handles trains between Baltimore and Washington, and at various other points, the road operates passenger trains of considerable local importance; and it is in service of this kind that the ten-wheeler shows up to advantage.

Incidentally, the B. & O. is another road which has shown great general improvement within recent years. Most commentators stress the historical interest of this road; which is, indeed, very great. On the other hand, it is now time to take some notice of the modern achievements which have placed it among the most important of the trunk lines. Among these improvements may be mentioned the adoption of new locomotive types and the rebuilding of old ones, the purchase of handsome steel passenger cars and the retirement of obsolete equipment, the laying of heavier rails and the provision of speedy, reliable and courteous service to Chicago and St. Louis. This is a very fine record of accomplishment.

Many of those who read these lines will remember the "Harvey Springstead," Class G-15-A of the Erie Railroad; a 4-6-0 built by Baldwin in 1903, and rebuilt by the railroad company in 1915. Here was a case of successful modernization.

Others will know something of the very handy Class J-25 of the Lehigh Valley, built in 1917 and still going strong.

Still others can discuss eloquently the "Copper Head" ten-wheelers of the Atlantic Coast Line.

Of interest, also, are the modern—or modernized—4-6-0 engines on the Southern Pacific.

These examples, taken at random, give some idea of the extent to which the 4-6-0 is employed in America. They indicate that this type has rolled quietly into the place necessarily vacated by the 4-4-0, and that the ten-wheeler has an interesting future in fields which do not require the larger types of motive power.

Roads which possess old ten-wheelers in fairly good condition might find it worth-while to look into some of the less expensive appliances that are designed to increase efficiency. There are those milk-trains, baggage and express trains, fast freights and certain "extras" that could be handled very nicely by 4-6-0 engines which had received enough pep and ginger from well-known devices to put them back on the active list.

The railway motive power officer of today enjoys advantages which were unknown years ago. Chief among them is the expert advice of the engineers who have done so much to make the design, construction and maintenance of locomotives a fine art.

Record Shipment of Powerful Electric Locomotives Delivered to Long Island

Fourteen electric locomotives, comprising the largest single shipment of its kind ever made, has been delivered to the Long Island Railroad.

These locomotives are to be used in shifting service on the Bay Ridge Division of the Long Island Railroad which is now under construction. Each locomotive is rated at 1,000 horsepower, weighs 75 tons and can be operated at a speed of 25 miles an hour. At a speed of 12.4 miles an hour the drawbar pull is 44,200 pounds. The locomotives can be operated individually or for heavy service, two in multiple as a two-cab locomotive. When so operated they constitute the most powerful shifting engines ever built. The mechanical parts were built at the Altoona Shops of the Pennsylvania Railroad from where the record shipment was started. All electrical equipment was supplied by the Westinghouse Electric & Manufacturing Company.

These locomotives represent one more step in the development of the electric service of the Long Island Railroad. They are designed for the purpose of establishing a standard switching locomotive, not only for the Long Island Railroad, but for the Pennslvania Railroad System in general, and all of its affiliated lines.

Since 1905, when the first electric lines were placed into operation, the electrified track miles of the Long Island Railroad have risen from 64 to 300; the current consumption from 20,000,000 to near 200,000,000 kilowatt-hours a year; the number of multiple-unit cars from 187 to 904; the car miles from 3,500,000 to 35,000,000 per year; and the passengers carried annually from less than 10,000,000 to 100,000,000 per annum.

These increases are around the order of 1,000 per cent, and are significant of the rate of development of Long Island. As everyone knows, however, Long Island is today growing more rapidly than ever, and the Long Island Railroad must anticipate the future requirements.

New Double-Unit Gas-Electric Cars

Four Brill-Westinghouse 70-Ft. 6 In. Cars for the Lehigh Valley Railroad Are Equipped with Two 250-Hp. 160-Kw. Units and Electropneumatic Control

By J. G. Inglis, Railway Engineer, Westinghouse Electric & Manufacturing Company

Many years have passed since the first gas-electric rail car went into service. At that time its field of application was practically the same as it is today—that of eliminating unprofitable steam operation, with particular reference to branch line service. The cars used then were powered by engines ranging from 75 to 100 hp. and were of sufficient capacity to fulfill the demands made of them.

In more recent years the development of the internal combustion engine has allowed more horsepower to be concentrated in a given space, resulting in cars of greater capacity than formerly. This increase in capacity has made it possible for the gas-electric car to handle more and more of the traffic formerly handled by steam.

At the present time the amount of power available in gas-electric rail cars is such that the average steam railroad coach may be handled as a trailer when operating in the service usually found on branch lines. Translated into physical terms this means an engine horsepower varying between 225 and 275.

Fig. 1. Lehigh Valley Railroad Gas-Electric Train Consisting of Brill-Westinghouse Double Unit Motor Car and Trailers

The satisfactory performance of the dozens of gas-electric cars that are in operation has caused the railway operators to seek out other classes of service where they can be utilized profitably. The main requisite necessary before these units can perform any more work than they are doing now is more power and this, in turn, has resulted in the development of the double-unit power plant.

The Lehigh Valley Railroad is the pioneer railroad to make extensive use of double power plant gas-electric cars as they have recently purchased a sufficient number of them to handle the majority of their branch line service as well as some of their main line service. The most severe operating conditions are encountered on the lines from Elmira to Canastota and from Wilkes-Barre to Towanda and for these lines four Brill-Westinghouse cars have been specified.

The two cars which are to operate between Elmira and Canastota will replace train numbers 321, 322, 325 and 326. One of the cars will be arranged to handle passengers and baggage while the other will handle mail in addition. The car which will replace trains 321 and 326 will handle passengers and baggage. Seats for 80 passengers will be provided in a 54,000 lb. trailer and the passenger compartment in the motor car will be used as a smoking compartment only. In addition to the passenger trailer, a 53-ton express car will be hauled regularly between Canastota and Freeville while at times a 73-ton express car will be hauled over the whole line. The motor car will weigh 124,000 lb. without load, making a maximum train makeup of 219 tons without load.

The floor plan of the car which will operate as trains 322 and 325 is shown in Fig. 3. It will weigh 133,500 lb. without load and will be similar to the car shown in Fig. 1, except that the baggage compartment will be shortened to make room for a mail compartment on this train.

The profile of the line over which these cars will operate is rolling with long and severe grades existing in places. Grades of 1 and 1.5 percent are common while the most sereve one is a grade of 2.4 percent for 3.6 miles. The schedule speed is approximately 23.6 mph. and this, coupled with the severe grades and the heavy train makeup, makes the use of a double power plant imperative.

Two cars will be used on Bowman's Creek Branch between Wilkes-Barre and Towanda. One of the cars, similar to that shown in Fig. 3, will be arranged to handle baggage and mail and will operate as trains 504 and 505. The passengers will be carried in a passenger trailer having a total seating capacity of 80, seats for 23 being in the smoking compartment. In addition to hauling the passenger trailer, three empty milk cars of 129 tons total weight will be hauled over part of the route. The estimated light weights of 123,000 lb. for the motor car and 54,000 lb. for the trailer will give a maximum train makeup of approximately 218 tons without load.

The car operating as trains 503 and 506 will be a straight baggage car weighing 122,000 lb. without load. This car will not carry passengers. The passengers will be carried in a 54,000 lb. trailer, a duplicate of the other trailer used on this line. In addition to the passenger trailer; as many as four loaded milk cars (228 tons) will be hauled at times. This will bring the maximum train makeup to 316 tons, the heaviest regularly handled by any gas-electric car in passenger service.

The profile of Bowman's Creek branch is very rolling and a large number of curves are also present. Grades of 2 percent are quite common as well as lesser grades of correspondingly greater length. Many of the curves are sharp enough to make necessary a reduction in speed so that the maximum power of the equipment cannot be used at all times.

While the floor plans of the four cars will be different, the exterior dimensions and general characteristics will be the same. Each car will have a length of 70 ft. 6 in. over the ends and will weigh between 130,000 lb. and 135,000 lb. depending upon the interior arrangement. A compartment, 13 ft. 10 in. long, at the front of the car will house the power plants, fans, control apparatus and the operator's cab.

Each of the two power plants will consist of a 250-hp. Brill-Westinghouse engine driving a 160-kw. Westinghouse generator through a flexible coupling. The unit, complete with the exciter, will be mounted on a common bedplate and an idea of the general appearance of the unit may be obtained from Fig. 2. The two power plants will be mounted longitudinally in the engine room and spaced 4 ft. 5 in, between center lines. This arrangement will permit free access to either side of either unit as well as giving an aisle between to permit entry and exit from the engine room. One of the units will be mounted with the generator facing forward and the other facing backward. This arrangement permits a greater aisle width and places a large proportion of the engine auxiliaries on the aisle side where they can be inspected with a minimum of effort. The arrangement of the units in the engine room is in the outline drawing.

The engine which has 6 cylinders, 7¼ in. bore and 8 in. stroke, is equipped with dual valves and ignition, aluminum alloy pistons, removable cylinder liners and is governed at 1,100 r.p.m. at which speed it will deliver 250 hp. The generator is self-ventilated, has a cast steel frame and is rated at 160 kw. By suitably proportioning the magnetic circuits and field windings the generator demand upon the engine is practically constant and this demand is automatically translated into the combination of speed and tractive effort necessary at the motors. The exciter is an integral part of the generator, having its armature on the extended generator shaft and its frame bolted to the commutator end generator housing. It performs the functions of exciting the generator, charging the storage battery and providing part of the energy for the lights.

There will be four Westinghouse type 557-D-8 motors per car, two fed from each generator. The motors have a nominal rating of 140 hp. and will be applied with the maximum gear reduction, using Nuttall helical gears and pinions. Maximum gear reduction results in maximum tractive effort per ampere and the high generator voltage available at low current values also allows high schedule speeds to be maintained. Motor cutout switches will be provided to enable either pair of motors to be cutout in case of trouble.

The control will be the Westinghouse unit switch type, arranged for single-end operation and housed in a cabinet in the engine room. This type of control is electrically controlled and pneumatically operated, making the operation of a double unit equipment as easy as that of a single unit. The duties of the operator have been reduced to an absolute minimum by the use of remotely controlled apparatus and by reducing the amount of control apparatus as much as possible. In addition to simplicity of operation, remote control results in safety to the operator and low maintenance charges. No high voltage, current-carrying apparatus in near the motorman as it is contained in an asbestos-lined switch cabinet. The rapid and positive opening and closing of the switches greatly reduces the arcing and burning, thereby prolonging the life of the apparatus.

The application of power to the motors will be governed by the throttle handle which will also serve as a master controller. Movement of the throttle handle from the "off" position will first close a toggle switch which governs the closing of the field and line switches. Further movement of the throttle handle will change the engine speed which, in turn, will change the car speed correspondingly.

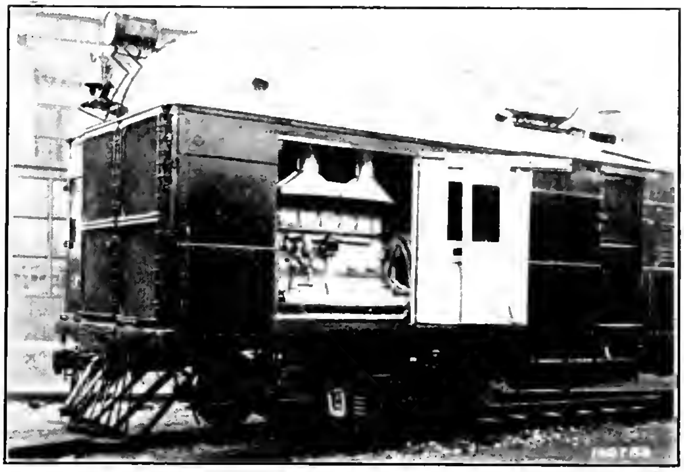


Fig. 2. Side-View Showing Radiator and Location of Engine of One Power Plant

Series-parallel control of the motors has been provided and will be governed by the position of a tumbler switch in the operator's compartment. A special feature of the series-parallel arrangement used is the fact that the tumbler switch may be used to pre-select the motor connection while the car is drawing power. When the operator wishes to make the actual change, the only action necessary is to return the throttle handle to the "off" position and immediately return it to its former position. This method reduces to a minimum the time lost in changing the motor connections and assists in maintaining a higher average accelerating rate and a higher schedule speed.

The direction of motion of the car will be governed by a plug switch placed near the operator. The insertion of the plug in the proper receptacle will establish electrical connections to throw the reverses to the desired position. An ammeter, placed in each generator circuit, will enable the operator to take full advantage of all the power available without overloading any of the apparatus.

Air to operate the brakes, control, etc. will be furnished by two Westinghouse DH-25, 600-volt, motor driven air compressors, each having a displacement of 25 cubic feet at rated voltage. The compressor motors will operate in parallel, being connected directly across either generator by means of a double-pole, double-throw switch.

The water circulating and cooling system will be arranged in a very interesting manner. Since the cars are for single-end operation, the radiator will be mounted at the front and will be divide into four sections. It will be offset to the left of the car in order to have room at the right side of the car for the operator's compartment. Immediately to the rear of the radiators will be an air chamber closed on the bottom and sides, but with an opening at the top. In this opening, slightly above the top of the radiator, will be placed two fans mounted side by side in a horizontal plane and each driven by a shaft projecting downwards to a vertical motor placed on the car floor. The normal operating speed of the fans will be 1,500 r.p.m., but a lower speed will be available by means of switches which will place the fan motors in series. This method allows the use of two operating speeds without the necessity of using external resistance. The fan motors will pull the air through the radiator, then upwards and finally expel it at the top of the car.

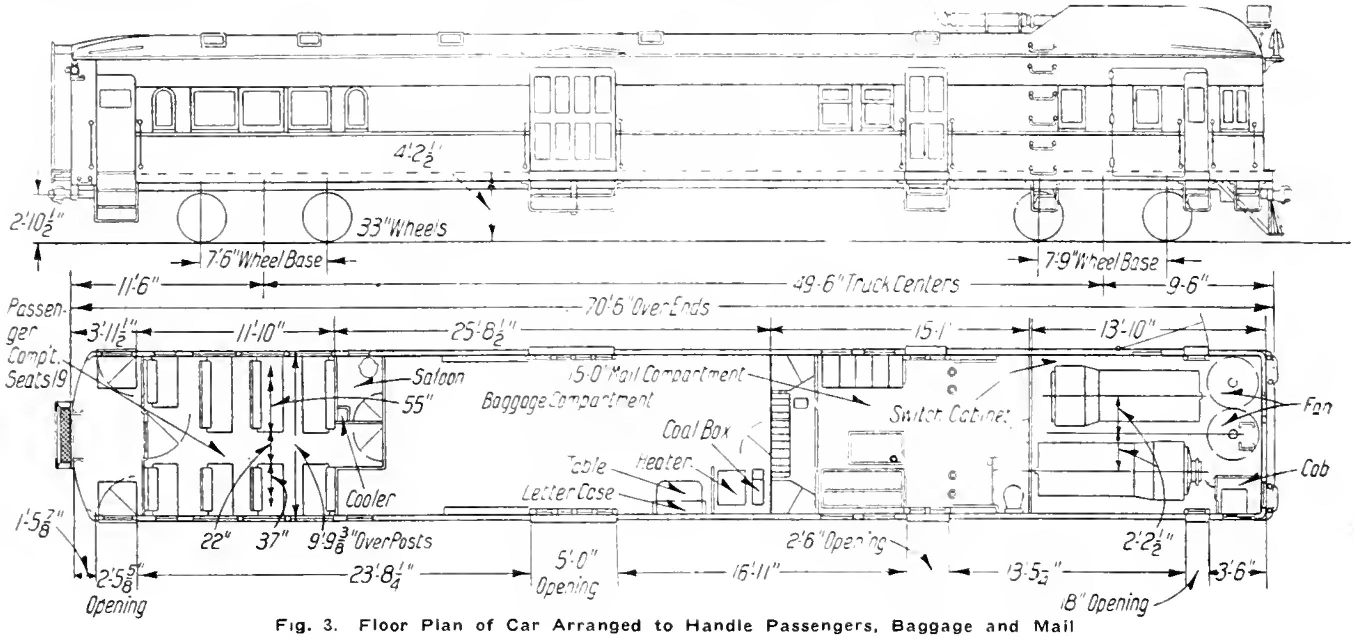


Fig. 3. Floor Plan of Car Arranged to Handle Passengers, Baggage and Mail

To further assist in the movement of the air a shroud or false roof will be placed at the front of the car, extending back about 8 feet and being open at the rear. The air will be forced into the space between the two roofs at the front and then will travel back towards the outside air. The expansion water tank will be so located in this space that the air exhausted by the fans will pass over the tank. The exhaust pipe will come through the roof into this space, the muffler being mounted to the rear of where the shroud ends.

Each car will be equipped with an Exide Ironclad storage battery consisting of 16 type MV-13 cells. The battery will be used to supply engine starting current, to energize the exciter field and to provide lighting. It will be charged normally by the exciters, although a receptacle will be provided in order that an external charging source may be used if desired. A Safety Car Heating and Lighting Company's charging and lighting regulator will regulate the exciter voltage for battery charging and provide constant voltage across the lamps.

That a good deal of interest will be exhibited in the equipment and performance of these cars is self evident. The use of 500 hp. in the engine room marks the concentration in one passenger car of more power than has been used heretofore. The widening of the field of application into light main line service will also attract its share of attention. The fact that electro-pneumatic control may be arranged to govern the operation of two power plants as easily as a single unit indicates that the successful record of the many single-unit Brill-Westinghouse cars in service will be duplicated in the double-unit cars.

South Shore Line Builds Four New Electric Locomotives

The freight business of the South Shore Line has already shown a remarkable growth under an active corps of traffic experts who were put to work on the freight problems of shippers in the territory served immediately following the taking over of the company by Mr. Insull and associates.

Extensive improvements were made in the facilities for handling the freight business among them being the extending and double-ending of all sidings, remodeling and building of large platforms at freight stations and the construction of one new freight station.

Four receiving stations for freight were established in Chicago at vantage points throughout the city and the "over-night" delivery policy inaugurated. Under this system freight delivered at the receiving stations before late afternoon is ready at stations on the line for pickup the next morning.

The South Shore Line has an advantage over some other electrically operated railroads through the fact that steam railroad freight cars can be handled over the entire line from Kensington, Ill., to South Bend, Ind. Through the activity of its freight solicitors and traffic agents, interchange and switching facilities have been established with several of the nearby steam lines.

Through rates have also been established with several steam lines and other new tariffs are also being worked out. Private switching tracks have been built for several new industries in the territory served and others have been laid for some of the old established industries.

The progressive tactics of the present management in developing freight business has made itself felt and surprising increases have already been shown in the monthly reports on business.

Another situation which presented itself as a problem to be overcome was the fact that some of the industries closer to Chicago trucked their L.C.L. freight to that city in their own trucks. The fast overnight service of the South Shore Line and decreased cost of this service over trucking, is rapidly overcoming this form of competition.

Large freight receiving stations are maintained in each of the cities served by the South Shore Line and shippers are given unexcelled service at these stations. Tracing of delayed shipments by wire, close personal contact between South Shore Line solicitors and traffic agents of the shippers, courtesy, and other modern appurtenances are among the other factors contributing to the South Shore Line freight increase.

The freight handling equipment has been augmented recently by four 80-ton Baldwin-Westinghouse electric locomotives. Each locomotive has capacity for hauling trains in excess of 1,500 tons on comparatively level sections of the system, the weight of the train being adjusted according to the severity of the grades that are traversed. Short stretches of heavy grades exist between Kensington and Gary.

The locomotives can be operated in multiple providing a considerable range in tractive effort, and will have a combined total output of 3,200 horsepower.

PRINCIPAL DIMENSIONS, WEIGHTS AND RATINGS

Axle classification	B-B
Motors, axle mounted	
Driving wheel diameter	42 in.
Rigid wheel base	104 in.
Length over bumpers	434 in.
Maximum speed	45 mph.
Total weight	160,000 lb.
Horsepower—1 Hr. S.F.	1,600
Tractive effort—1 Hr. F.F.	29,200 lb. at 18.6 mph.
Tractive effort—Cont. F.F.	17,200 lb. at 21.7 mph.
Length between coupler knuckles	39 ft. 4 in.
Length over bumpers	36 ft. 2 in.
Height, top of rail to roof	12 ft. 1½ in.
Total wheel base	27 ft. 0 in.
Rigid wheel base	8 ft. 8 in.
Truck centers	18 ft. 4 in.
Width overall	10 ft. 7 in.

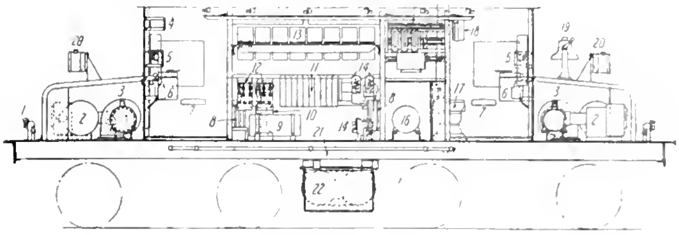
These locomotives were built in accordance with specifications of Mr. Insull's engineers and incorporated the highest standards for main line locomotives.

The cab is of the steeple type. The hoods, one located at each end of the cab, house the blower equipment and the air compressors. The remainder of the equipment is located inside of the cab. The locomotives are designed to negotiate curves of small radius. The cab is carried on two two-axle, swivel trucks, of rugged construction with substantial side frames. The rigid truck bolster is of heavy cast steel bolted to the side frames. Hangers from this rigid bolster carry through semi-elliptic springs, a spring bolster containing an unusually large centre bearing. The cab is thus spring-supported on the truck frames, the truck frames being in turn spring-supported in the usual manner from equalizers on the driving boxes. Each truck is provided with spring-mounted side bearings. The cab underframe is built of heavy rolled steel channels, the side and transverse members being connected by knee castings. Heavy and bumping and coupling castings are bolted to the longitudinal underframe channels.

The cab is built of standard rolled steel sections, the carlines are Z bars and the sheeting No. 14 gauge. The entire framework is thoroughly braced and fastened to withstand the shocks and bumps to which it will be subjected. The interior of the cab is arranged with a central equipment compartment having an aisle along each side. The switch compartment is completely closed, with removable doors of convenient size giving easy access to the equipment. Ventilators are provided in the roof of the locomotive directly above the equipment cage. By using expanded metal doors at the base of the compartment and solid doors at the top, a chimney effect is produced and a continuous flow of cold air is provided through the switches and grid resistors.

An elevation and plan view of the apparatus layout is shown in accompanying illustration. The steeple cab arrangement which permits the housing of the blower and compressors outside the main cab assists materially in obtaining a quietly operating compartment and leaves liberal space for placing the detail control apparatus to obtain the most desirable access for proper inspection and maintenance. The switch units and resistors are extremely accessible and they obtain a maximum of ventilation.

The two trucks each are equipped with two Westinghouse type 358-D-5, 750-1500-volt field control, forced-ventilated motors. These motors are inside axle hung with single reduction spur gears, having a gear ratio of 16:72.



Plan of Equipment Layout in Cab of South Shore Line Electric Locomotive

The complete assembly and method of control, both in the main and auxiliary circuits, will be explained further and is typical of the practices of Mr. Insull and his engineers in giving maximum reliability with ease of operation, inspection and maintenance.

Current collection is provided by a spring-raised, air-lowered double-shoe pantagraph. The pantagraph is normally released by an electro-pneumatic trip cylinder. A mechanical unlatching device is provided also so that in the absence of air supply the pantagraph may be released by tripping the unlatching device with a hook stitch.

A manually operated grounding and locking switch is provided with each pantagraph and is arranged so that when the switch is closed the pantagraph is held in the "locked down" position and the manipulation of control switches in the cab cannot release or raise it. The locking device consists of projections on the end of the grounding switch knife blade. The blade engages the switch jaws on the blade projection and remain in the "down" jaws carried on the pantagraph frame. Upon releasing the pantagraph with the grounding switch closed the pantagraph in attempting to rise will engage the switch jaws on the blade projection and remain in the "down" position.

The unit switches for the control of the motors and connections to the line are assembled in the main cab as illustrated.

Each switch is an individual unit and can readily be removed as a unit. These switches are specially designed for heavy duty and employ extra heavy contact tips, arcing horns and other parts, thereby allowing a good margin of capacity. An improved type of blowout is used which increases the arc rupturing capacity of the switch and the life of the arcing parts.

Many of the parts of the main control switches are interchangeable with corresponding apparatus employed with the motor cars of the South Shore system.

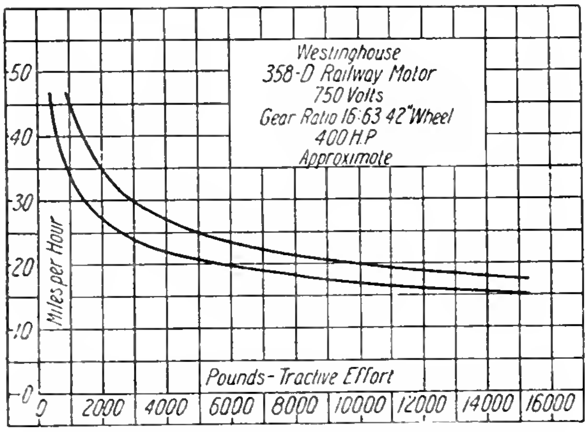
The resistance has been liberally designed to take care of the severe service incurred in combined switching and through freight application.

The master controller which operates on a 32-volt circuit contains 19 notches, ten in series and nine in series-parallel. There are four economic running positions: namely, full and short field connection in both series and series-parallel.

Overload protection is provided at all times by means of a main fuse and also by overload relays. Each pair of motors has an individual relay and if for any reason any relay opens, all of the motors are disconnected from the line. To find which pair of motors caused the relay to operate, it is necessary only to find which relay functioned, which, of course, is apparent upon inspection.

The reset circuit to the overload relay is established only when the master controller is in the "off" position and the reset switch is operated. This makes it impossible to "reset" the overload relay with the main circuit switches closed. Push button control of magnetic contactors for all auxiliaries in the high voltage circuit adds additional safety to the operation of the locomotive.

All auxiliary control switches operated by the engineer are mounted in a single push button set similar to that used on the motor cars, and the pantagraph, headlight and reset switch, are conveniently and safely controlled from this set which is located near the engineer. These sets are provided at both operating positions.



Performance Curve of Type 358-D-5 Locomotive Motor

Receptacles are arranged at both ends of the cab to provide for multiple operation. Either end of a cab unit can be connected by means of jumpers to a second cab.

Each locomotive unit is equipped with a 2½ kw. 1500-32-volt motor-generator set and an auxiliary battery. The motor-generator set is interchangeable with the sets employed on the motor cars and the system and the method of operation is similar to that described in a previous article on the motor cars.

The two blower sets employed per unit consist of a 1500-volt motor driving a Sirocco fan. The equipment is mounted on each end of the locomotive and supplies air to each end of a common duct running the entire length of the locomotive. A baffle is provided at the mid-point of the air duct. Under ordinary operating conditions this baffle is closed and each blower supplies air to the two motors nearest to it. In the event of a failure of one blower equipment the baffle can be opened and the air duct closed at the end adjacent to the blower motor which is out of commission. A suitable plate is provided for this purpose. With this arrangement the locomotive is supplied with sufficient air in an emergency.

Each unit is equipped with two Westinghouse type D-3-F compressors having a displacement of 35 cubic feet. The compressors are operated by a 1500-volt motor.

The air brake equipment is Westinghouse type 14-EL. This equipment is the adaptation to electric locomotives of 6 ET equipment, the recognized standard for all steam locomotives in this country. This apparatus includes an independent (straight air) brake for handling the locomotive alone, and the standard quick action automatic brake for both locomotive and train. Two brake cylinders per truck are used to apply the braking effort to the locomotive. The brake shoes are inside hung and are so designed, that adjustment can be made for wear on the shoes. A gearless hand brake is provided and works in conjunction with the air brake.

Economy in Wheel Service

A Paper Read Before The Car Foreman's Association of Chicago

By C. T. RIPLEY, Chief Mechanical Engineer, Atchison, Topeka & Santa Fe Railway

Most railroad officials have been too prone to consider the subject of wheels and their inspection a finished book and to devote their time and efforts to the study of other items. The fact of the matter is, this subject is far from a finished book and it affords chances for saving which make it a veritable gold mine. What I wish to do is to bring to your attention some of the ways in which the problem can be attacked.

This question of wheels and wheel service is one which I have found intensely interesting and the longer I work with it the more I realize how much there is to learn about it. The best way to learn it, I have found, is to spend as much time as possible in the wheel shops and in the car yards for it is through the men who are actively working with this material that most is to be learned. What I am saying to you here is information I have obtained by this contact with car inspectors, wheel shop men, etc.

I will not in any way present data favoring one type of wheel against any other type of wheel, for I fully realize that local conditions are the governing factor as to the proper type of wheel for any particular service, but inasmuch as the majority of wheels in service are cast iron, I am going to devote most of my time to a discussion of this particular product, though I will touch to some extent on steel wheels.

The average railroad car inspector, through long experience, is highly qualified to pass on defects in wheels. However, certain unfortunate conditions have arisen which have tended to take away from the inspector the exercise of proper judgment. There has been too great a tendency to condemn the inspector, write him up, give him demerits and even discharge him for passing wheels which are condemned by another inspector farther down the line. In many instances the second inspector may be the one who has made the mistake, but there has been no machinery by which this could be checked up and the blame put upon the proper party. The inspector is almost never praised or given credit for letting wheels run when they are perfectly safe to run and thus saving his employer money. What has been the result and what would you or I do if we were in the inspector's position under similar conditions? We would do just as many of them have done, become more and more rigid in our inspection and condemn any wheel which there was the least chance of the next inspector down the line condemning. Furthermore, we would be looking for a chance to get something on the next inspector. As a result of this the rigidity in inspection has increased and increased until many wheels are condemned which are perfectly safe for service, with a resultant loss of large amounts of money. What we need is a change in the system, whereby an inspector will be condemned for passing a wheel which is truly dangerous but will also be condemned for taking out wheels which are safe to run and will be given credit for catching dangerous wheels. In cases of difference in opinion between inspectors, some competent third party should pass on the matter and make a fair decision.

There are two general classes of defects. The first class are those which are liable to cause accidents, and we cannot be too rigid in our inspection for these particular defects. I would be the last person to recommend any let down in their inspection. The defects to which I refer are cracked plate, seams and loose wheels. The other group of defects are, in extreme cases, liable to cause trouble, but generally speaking they are not in the same group as those enumerated.

Cracked Plate Wheels

The railroads which operate in mountainous territories have always been confronted with the chance of accident from cracked plate wheels. The cracking of the plates results as a general thing from the heating of the rim at such a rapid rate that the stress set up due to difference in temperature between the hub and rim is so great that it produces a stress in the plate greater than it can stand. If the wheel was heated uniformly, the plate would not crack. In order to check new wheels we subject one wheel out of each heat and size to what is known as a thermal test. In this test a band of hot metal is poured around the rim of the wheel and if the wheel does not stand this treatment for a specified number of minutes without cracking, the lot of wheels is rejected. This test catches any lot of wheels in which the general nature of the metal or the annealing is uniformly bad. However, we cannot thermal test every wheel and certain weak wheels do get through. The most important feature in the prevention of weak wheels is the annealing process at the foundry. The wheel manufacturers have, through their studies, learned that the condition of their pits is a vital factor, and the modern annealing pit is of very different structure to that of former days. In most foundries there has been a marked advance in practice. The old red top wheels are almost unknown. Occasionally there is a delay in getting a hot wheel from the mold to the pit and this frequently results in the weakening of the wheel. Other factors which make for weak wheels are dirt in the plate and shifted pan cores. The change from the old Washburn plate to the arch plate type of wheel was a great help in the prevention of weakness, due to dirt in the plate. In the Washburn type there was a skimming action at the juncture of the plates, which resulted in the accumulation of dirt at this point. In the arch plate type the dirt is scattered instead of being concentrated. In some wheels now being tested raised rings were put on the outside plate of the wheel which serve as skimmers to collect the dirt and these are apparently helpful. Incidentally, when these wheels do, cracks seem to run around inside these rings, which is more satisfactory than having them go out to the rim.

The biggest advance toward the prevention of cracked plates is on a new design of wheel now being developed, known as the single plate wheel. In thermal tests, this wheel stands a great deal more than the standard double plate type. The metal is concentrated in the plate, giving a thicker plate instead of being scattered out in brackets, double plate, etc. It is my personal opinion that this wheel will ultimately supersede all of the present designs, though further service tests are necessary to prove the desirability of this design.

We should give the wheel more protection in service to help prevent cracked plates. The operation of a long freight train down mountainous grades can be handled in such a way as to protect the wheels by getting the heat into them gradually. If the braking at the start is less severe and if cooling stations are established, less cracked plates will result. The improvement of the triple valve to prevent kickers will give the engineer confidence in applying the brakes at low speeds, which will also protect the wheels. This improvement can be secured by the use of heavier triple valve release springs and I hope the time will come when all of the railroads will go to this small expense not only for the protection of the wheels but for the protection of the equipment and the trainmen.

We have found that inspectors frequently take out wheels for cracked plates when in reality the plates are not cracked, there is simply a line on the surface which looks something like a crack. However, this is such a dangerous defect that I do not believe we should tell an inspector to take any chances. If inspection at the wheel shop shows it is not cracked, it can be put back in service, but even here care must be used. Serious as the cracked plate problem is, I believe the introduction of the single plate wheel, and certain improvements in braking practice, are going to practically solve it.

Seams

It is now very generally admitted by wheel manufacturers that a seam is a foundry defect resulting from improper pouring of the metal or in the quality of the metal. It is one of the most difficult defects to locate, inasmuch as the seam is ordinarily covered over with good surface metal and the wheel will at times break before the seam can be seen. It is common experience to find that the majority of wheels which break because of seams do so fairly early in the life of the wheel, as indicated by the thickness of the flange. Inspectors should condemn a wheel which shows the slightest indication of seams in the throat, for there is no telling what the extent of the seam may be. Seams farther out in the tread are less common and less dangerous in service. The best remedy for this trouble is better foundry practice, though the reenforced flange which is now in use on a good many railroads is being recommended by some of the manufacturers and may be helpful in preventing breakage of flanges, even though there is a seam present.

Loose Wheels

The loose wheel is an aggravating defect. We are constantly having wheels condemned by inspectors as loose, which when taken to the wheel press are found to be tight. The inspectors seeing an indication of oil working out of the fit very properly condemn a wheel as loose and we cannot ask them to change this practice, but what we can do is to mount the wheels in such a way that no such showing will appear unless the wheels are actually loose. The trouble is that many wheel shops are using the wrong material for coating the wheel seat of the axle. They are using materials which are thinned down with light oils, which are unsatisfactory. Some roads are having success with the use of brown mineral paint, but the best material to use is white lead and linseed oil of a proper consistency.

Chipped Rim

Rule 78 of the Interchange Rules merely specifies the distance from the throat of the flange to which this defect may extend. Unfortunately, this does not properly cover the situation. There are some cases where there is small surface flaked out of the tread, which falls within the gage limit. Such a wheel is absolutely safe to operate, but technically the inspector is right in condemning it. There are too many wheels condemned for this defect. We have plenty of width of tread in our present design wheels to run with slight defect at the outside of the tread. Unfortunately, it is hard to write a rule which will cover every case and particularly cases where the breakage slopes inwardly under the rim. Our inspectors can, however, be taught to use judgment in gaging this defect and it is hoped that some time the rule can be changed in such a way as to better cover the proper gaging. The greatest advance toward the prevention of this defect has been the development of the so-called lip chilled wheel.

In this wheel the chill runs to the outside of the tread instead of having a narrow sand rim as was the past standard. It was found that the grain at the juncture of the chilled section and the sand rim was of such a nature as to invite cleavage. Certain modern types of frogs which include guard rails give the outside of the rim very hard service and we need the best conditions at this point to meet this service. I believe that the lip chilled wheel will reduce the chipped rim defect at least 50 per cent.

Worn Through Chill

Worn through chill is strictly a judgment defect, but we have found that many wheels are taken out for worn through chill which actually have a large amount of chilled metal left in them. In the inspection of new wheels, a check of the test wheels is always made to determine the chill and very few wheels with chills less than ⅝ in. in the center of the tread are found. Therefore, with our limits of wear there should be very few worn through chill wheels. There is an opinion among some inspectors that the worn through chill wheel is a dangerous wheel at all times. This opinion is hardly true and it is our opinion that a worn through chill wheel should be allowed to run until there is some indication of flatness at this point. Mere judgment passed on the feel of the metal or on the mottled appearance is not sufficient to definitely establish worn through chill. If a hollowness starts to develop at the point, the wheel should undoubtedly be taken out, as the chill is worn through. Generally speaking the term, "Worn Through Chill," appears entirely too often on inspectors' reports.

Vertical Flange

The vertical flange is the most common condemning defect in cast iron wheels. There is considerable question as to the correctness of the ⅞ in. limit which now covers the cast iron wheels for cars of 80,000 lb. capacity and over. The main purpose of this gaging is to prevent the splitting of frogs. There is no reason why the cast iron wheel will split a frog any more than a steel wheel which carries a 1 in. limit. Therefore, it is hard to understand why we should have a ⅞ in. limit. The strength of the flange is supposedly taken care of by the thin flange defect rule. There is a good deal of misunderstanding among the inspectors as to the gaging of vertical flanges. Some of them have an idea that if the flat surface on a flange is ⅞ in. high, it is condemnable as vertical. This is not the way the rule reads or is intended. In order to be condemnable the bottom of the notch on the gage must touch the flange of the wheel. Furthermore, when the standard A. R. A. gage is used to measure ⅞ in. vertical on a wheel where the tread is worn the gage is cocked and an incorrect reading results. To overcome this, some roads have cut another notch at the ⅞ in. limit on the longer side of the gage. The gage is then applied on its narrow edge and the effect of the hollow wear in the tread is eliminated. This practice is apparently justifiable under the rules as written.

Shell-Outs

The shelled wheel is apparently not as common a defect as it formerly was. I believe this is due to improvements in foundry practice. Its measurement is a simple matter and very few mistakes are made in this gaging. Most of the roads consider this a foundry defect and hold the manufacturer responsible, though it is admitted that sliding on the rail may contribute to its development. An important feature in this connection is that inspectors call certain defects shell-outs when they are not shell-outs. A true shell-out has the appearance of an oyster shell with a high center. A wheel which has a comby condition from brake burn is very frequently called a shell-out, but this is a mistake and inspectors should be instructed to properly designate the defect. There is practically no danger from this defect, but it is harmful to both track and equipment.

Slid Flat Wheels

The slid flat wheel is the most common defect in mountainous territories. Their number has been greatly reduced by the education of the enginemen in the handling of their brakes, but we will always have large numbers of such wheels. There is a way to save them, however, and that is by grinding. We have advocated this practice for many years. We have two grinding machines operating on our railroad and they pay for themselves every six months, conservatively speaking. We know this work can be done at a cost of a little over a dollar a pair and why it is not gone into by more railroads than have gone into it, I do not understand. We have found the ground wheel truly round and an excellent wheel for service. We must, of course, use judgment in selecting the wheels for grinding, as there is no economy in grinding wheels which have badly worn flanges, brake burns in the tread or are low in chill. The only trouble with which we are confronted is the hauling of wheels long distances to the points where the machines are located. We naturally locate the machines near heavy grades where the maximum number of wheels are slid flat. It has been suggested that the way to meet this situation is to mount a machine on a car and thus make a traveling grinding shop. A portable machine has been developed, but it only grinds a short distance to either side of the slid flat. Some railroads feel that this is the proper practice, but so far the American Railway Association has not seen fit to endorse the practice, since it appears that this practice will result in making the wheels more out of round and every effort is being made to get the wheels more truly round. Whatever the practice may be, the fact remains that large sums of money can be saved through the practice of grinding slid flat wheels. I am inclined to believe that it would pay us to grind all new wheels, in order to remove the eccentricities due to casting or to improper boring. It is an interesting fact to note that trainmen are anxious to have ground wheels under their cabooses, for they have found that their cars ride much better with these wheels.

Remount Gage

The remount gages shown in the Rules of Interchange have not been given the use which they should have. Out of fairness to car owners, no wheels should be applied and billed as second hand, which will not pass these gages. It is realized that many wheels that would be condemned by this gage, are worth remounting and using, but they should not be used in a foreign car as the billing prices are based strictly on their use. The American Railway

Association is making every effort to bring the importance of this matter to the railroads, and you gentlemen can help by insisting on the use of the gages. Their design is based as nearly as possible on the half way point on the wear of the wheel. The change in the gages made a year ago made them less restrictive and you should be careful in your shops to see that the right gage, as now specified in the Rules, is in service.

Mounting Gage

The standard gage for the mounting of cast iron wheels is a subject about which there has been a great deal of controversy. There are now several million re-enforced flange wheels in service. On these wheels the standard mounting gage cannot be properly used. Furthermore, this gage cannot be used when two maximum flange wheels are mounted on the same axle. Difficulty is being found by wheel shop inspectors when they try to apply the standard mounting gage to these re-enforced wheels. Something will have to be done to straighten out the situation. The suggestion has been made that the gage be opened up at each end on both the flange and throat side 3/64 in. This will still maintain the basic measurement from the throat to the back of the flange of 4 ft. 6-29/64 in. The only real difference will be in re-enforced flange wheels, in which case the throats of the flanges will be closer to the rail. This however has been passed on by the Committee of the A. R. E. A. and approved. In fact there is an opinion among many track men that this wider spread of the wheels will lessen both rail and flange wear. If gage is changed in this way it could be used on both the standard flange wheels and on re-enforced flange wheels. Its applicability to steel wheels would be somewhat of a question, but in reality the only proper way to mount steel wheels is with the back to back measurement, as has been recommended by the A. R. A. This question of the mounting gage is a live one and some action will probably be taken with it in the near future.

In discussing defect limits earlier in this paper, I referred strictly to the limits of the defects for the condemnation of the wheels under the car. There must of necessity be another set of limits which we might term shop limits. For example, we might have a pair of wheels one of which takes the gage and the other, while it does not take the gage is so close to it that it would be poor economy to remount the wheels. There is some intermediate point at which condemnation of these wheels in the shop should take place. However, in permitting the men to use lesser limits in gaging for this purpose, we must use a certain amount of precaution. There is always a tendency in the wheel shop to find some excuse for throwing away a second hand wheel. It is more or less of a nuisance to find a mate wheel and to find an axle with a big enough wheel seat. The production records look much better if nothing but new wheels are mounted, but let us not forget that the new wheel is worth about seven times the cost of mounting a second hand wheel and that we can afford to mount a wheel if it will give us approximately a year's service.

While speaking of these shop limits, I wish to emphasize the importance of good wheel shop practice. There is not enough appreciation of the importance of properly boring wheels, turning axles and mounting wheels. Improperly mounted wheels are not only dangerous but result in short life of the wheel and waste of money. The American Railway Association realizes the importance of this subject and has been preparing a manual, indicating as well as possible the best shop practice. It is realized that all of these practices cannot be applied in all shops, but it should at least result in the extensive study of wheel shop practice on the individual railroads and an improvement in cars which are in active interchange. A poor practice in the shop of a foreign road may result in both accident and expense to a neighboring road. Consequently, we are all interested in what the other fellow does. I could spend two or three hours in the discussion of the details of wheel shop practices, but I do not think I should burden you with this discussion. However, I do want to impress upon you what an important part of railroad work this is.

The defects found on steel wheels are simpler to measure than those on cast iron, but I think if anything there is less care used because of the idea the inspectors have that nothing is lost turning a wheel except the labor. They frequently say they take a wheel out before it reaches the condemning limit, because they will save metal in turning thereby. This is a fallacy and if this were true the defect limits should be changed.

In closing, I wish to emphasize the great importance of this subject of wheels. It is a veritable gold mine and if you will mine it properly you will be amazed at the results. I think it is of such importance that every railroad of any size should appoint a staff officer whose sole duty would be the handling of wheel work and he should have organized under him a committee composed of car department officers, chief inspectors, wheel shop foremen, etc., which will meet at regular intervals to discuss the problems involved in wheel work and to formulate recommendations for standard practice. I know the railroads are overburdened now with committee work, but if there is a chance to save, surely this extra trouble is worth while. The staff officer must be carefully selected and he must be a man who can handle the work without antagonizing the local officers. He should take the attitude of helpfulness to these men and not of criticising them or reporting them to their superior officers. He should be open minded and eager to learn from every man along the line, however humble that man's position may be. No one knows all about this big subject and every one can contribute his share to the fund of knowledge. The staff officer should gather all the suggestions and information he can pertaining to this work and put it out to his committee and application.

I cannot help but pay tribute to the work and attitude of the wheel manufacturers, and here I refer to the cast iron wheel makers, the wrought steel wheel makers and the cast steel wheel makers. They are all working actively to improve their product and they are making real strides toward this end. They are by no means at the end of the road and I look for great things in both improved wheel design and improved methods of manufacture. The intelligent efforts being put into this work are bound to give results and the railroads are going to be the ones who will benefit by it. My own attitude is that we should do every thing we can to help all of them in their experiments. One striking thing is the attitude the manufacturers have taken during this program of conservation of wheels. It might be thought that they would be opposed to it because it reduced the purchase of wheels, but big business men that they are, they realize that in the long run the better use of their material is the best thing for their business.

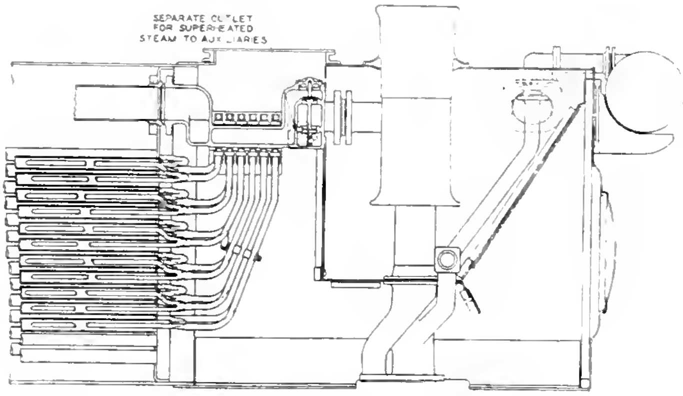
I must say that throughout this work they have given their active co-operation and invaluable advice. While we find fault with them due to trouble with their products, we must remember that this study, laboratory work, road experiments and general improvements are steadily going on and if we properly handle our work on the road, in our shops, in the gaging of our wheels and in operation of our trains, we will find that we are going to get better service and reduce maintenance of equipment costs.

A New Locomotive Throttle Valve

Novel Design Provides Economies in Steam Consumption

The steam locomotive still remains one of the most important or determining factors of railroad operation. All railroad men have their eyes focused on it, and feel impelled to consider improvements in design or new devices that may further increase its ability to move heavier trains at greater average speeds or do the same work with less fuel.

About seventeen years ago, a practical design of superheater was introduced to the railroads of this country, and has since become standard equipment. Quite recently the value of the superheater has been greatly increased by introducing the throttle between the superheater and the cylinders, improving the operation and handling of superheater locomotives in addition to the advantage of providing superheated steam for all auxiliaries as well as the engine.



Typical Application of Multiple Throttle in Combination with Superheater Headed

The number of locomotives of recent design which are equipped with smoke box throttle has been so large and their performance so satisfactory, that locating the throttle between the superheater and engine is considered good practice. With this advantage the superheater becomes a part of the boiler and is under pressure at all times. Thus a supply of superheated steam is constantly available for operating all auxiliaries, such as headlight turbine, air pumps, water pumps, stoker, steam grate shaker, soot blowers, whistle, atomizer on oil burning locomotives, etc.

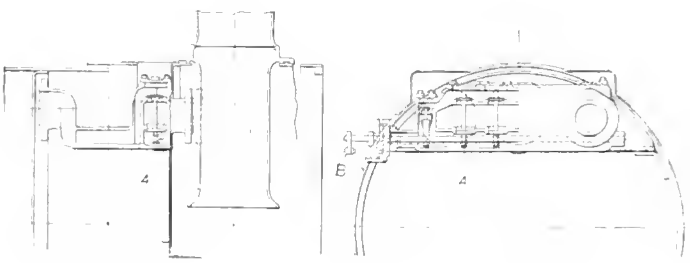
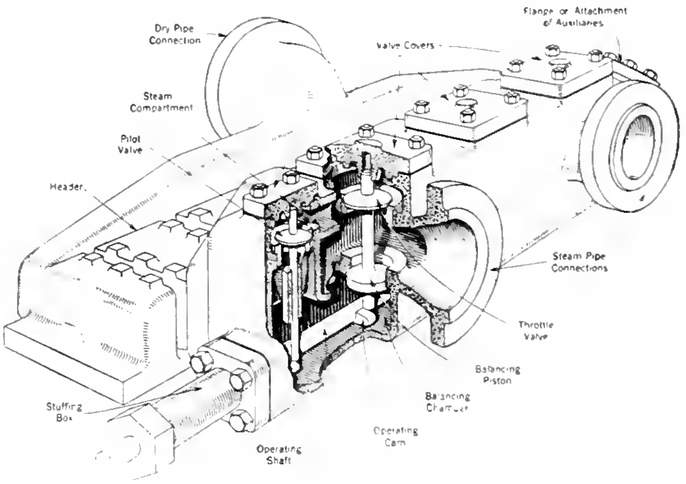


Illustration Showing Extended Valve Stem and Operating Shaft

With at least one of the auxiliaries, the blower, in use whenever there is any sizeable fire in the firebox, the flow of steam through the superheater will be sufficient to protect the units, thus avoiding the necessity of a damper arrangement for this purpose.

A further advantage due to the small volume of steam between the throttle and the cylinders, is that the locomotive responds immediately to a movement of the throttle, enabling the engineman to check the movement of the locomotive instantly. This is particularly of advantage on yard locomotives.

With these advantages and the auxiliaries consuming as much as 10 to 20 per cent of the boiler evaporation, the need for a satisfactory throttle to place between the superheater and engine became paramount. A new type of front end throttle has been introduced during the past year; i. e., the American Multiple Throttle. It consists of an improved superheater header of either the Type "A" or Type "B" design containing the throttle valves located in the superheated steam compartment on the forward side. This combination can be installed in practically every superheater locomotive containing the normal thru-bolt header.



Sectional Illustration of American Multiple Throttle in Combination with Superheater Header

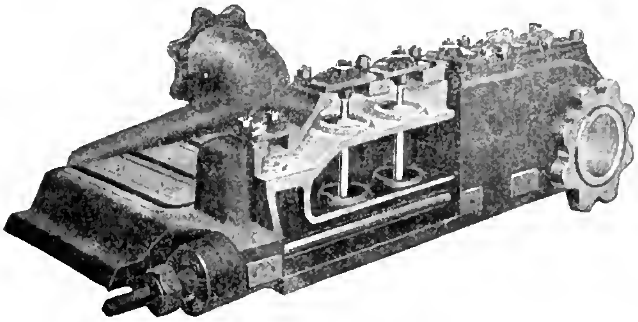
The throttle valves are of comparatively small diameter: $4\frac{1}{8}$ in. They are similar in construction to automobile engine valves and easy to keep tight, and are operated by a cam shaft similar to that used on an automobile engine. They are so nearly balanced that only a slight effort is required to move them. This balancing is accomplished by means of a pilot valve which opens first and admits steam to a balancing chamber preliminary to the opening of the main valves. The main valves then follow in succession, providing a perfect graduation in the supply of steam to the locomotive cylinders.

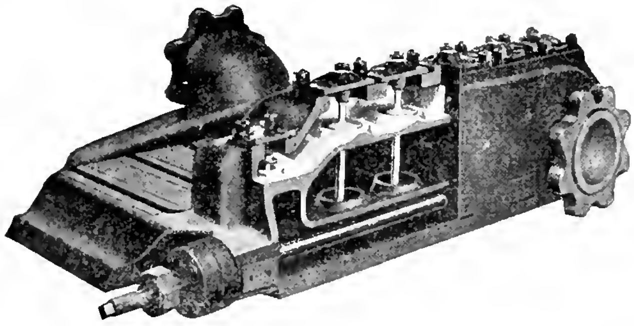
The small steel valves used in the throttle are not affected by high temperatures, so they are easily kept tight and remain tight. This eliminates steam leaking through the throttle, and the danger of the locomotive moving when unattended around engine houses, terminals and yards.

A removable cover is provided directly over the superheater header, in back of the stack on the smoke box, so that the valves are easily accessible. In case it should be necessary to do any work on the valves, they may be reached through the opening without having to enter the front end. With locomotives equipped with a shutoff valve in dome the throttle may be worked on while there is steam in the boiler. The cam shift stuffing box can also be packed while there is steam in the boiler. There are no bolts, rings, pins, cotter pins, rods, links, studs, nuts or other parts to become loose or broken and cause trouble in this throttle.

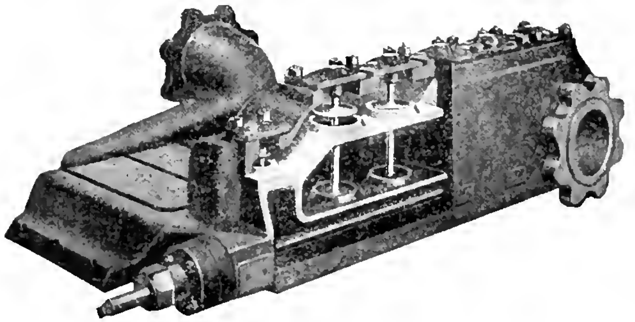
Through the use of this type of throttle the number of steam pipe joints in the front end is reduced to a minimum. This combination of throtle and superheater header requires only the usual steam pipes leading from the header to the main steam cylinders. The additional weight of the header with throttle combined over the header alone is only 400 lb. approximately.

The operation as shown by the following cuts is very simple. The operating lever is located in the cab in the same relative position as for any usual outside throttle. The first movement of the lever opens the pilot valve and permits steam from the steam compartment to enter the balancing chamber. This builds up a pressure under the balancing piston section of the throttle valve which is equal to that in the steam compartment. Further movement of the lever opens the first valve. The cams are so arranged on the operating shaft that when the first valve is cleared, the second valve starts to open and so on until all the valves have opened when the throttle lever is in the full position. Closing takes place in the reverse order, i.e., the last to open is the first to close, etc.


All Valves Closed

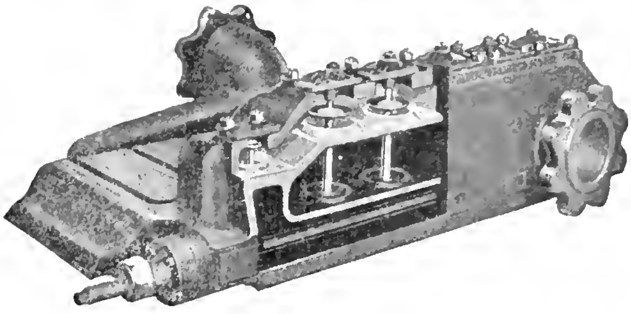

Pilot Valve Open

The only maintenance required for the throttle is that of keeping the stuffing box on the operating shaft packed and the grinding of the throttle valves. Since the stuffing box contains a rotating rather than a sliding shaft it should not require packing except at long intervals. Experience has demonstrated that the grinding of the valves is only required at each shopping of the locomotive.


Pilot and One Main Valve Open

It will be noted that while the operating cams open the pilot and steam valves, their closure is effected by excess pressure in the steam compartment.

In order to provide means whereby the engineer could close the valves by positive mechanical means in the event of any of them sticking and remaining partially or wholly open, the valve stems were extended at the lower end with a reduced section with a button on the end of the stem. The cams on the operating shaft are also extended and forked so as to straddle the reduced portion of the valve stem. This is shown in one of the illustrations. It operates on the principle of a "scotch cross head." The engineer has the same control over the closing of the valves as with any other type of throttle valve mechanism.


Pilot and Two Main Valves Open

Detroit Toledo & Ironton Railroad Equip Cabooses with Linoleum Floors

A durable linoleum floor covering of a neat and attractive appearance is now being installed in all cabooses. Forty of these are to be so equipped within the near future.

The work of fitting the linoleum is being done at the South Yards, Ecorse, Michigan, and at the Napoleon and Jackson, Ohio, yards.

The linoleum floors are clean and sanitary and can be kept so with a minimum of labor. The product, unlike wood, will not absorb water to any extent and a little effort with a wet mop will quickly remove any dirt. Then, too, they are much warmer in winter than the wooden floor. Also, under ordinary conditions, linoleum properly laid will outlast wood as a floor covering.

Wooden floors in cabooses were frequently varnished to keep them at the high standard of maintenance required and to cover up mars in the surface. This covering quickly wore off, requiring constant attention. With the linoleum floors, this will be eliminated.

The application of the linoleum requires considerable labor. The floor is covered completely instead of cutting around the equipment. This necessitates the removal of everything inside the caboose. Metal racking, stove, center posts, ladders, chairs, etc., are all taken out.

Before fitting the linoleum the entire floor is covered with a cardboard pad which is cemented securely to the floor. The linoleum is then cut to fit the floor and cemented securely to the cardboard. Two pieces are used, although the dividing seam is barely discernible.

A considerable saving is now being effected over the time required for the completion of the first caboose. About 24 hours were required to complete the laying of the linoleum in the first unit. However, the third one was completed in about 14 hours and a still further time reduction is expected on the remainder to be equipped.

The completed units are probably the first cabooses in this country to be equipped with floors of this type.

Railway and Locomotive Engineering

A Practical Journal of Motive Power,
Rolling Stock and Appliances

Published Monthly by
ANGUS SINCLAIR COMPANY
136 Liberty Street, New York
Chicago Office: 168 North Michigan Avenue
Telephone Rector 0746. Cable Address "Locong," N. Y.

Harry A. Kenney, Prest. and Man. Ed.
J. Snowden Bell, Associate Editor.
W. E. Symons, Associate Editor
Thomas P. Kenney, Secretary.

LONDON REPRESENTATIVE
The Locomotive Publishing Company, Ltd., 3 Amen Corner, Paternoster Row, London, E. C. England.

SUBSCRIPTION PRICE

$2.00 *per year,* $1.00 *for six months, postage paid in the United States, Canada and Mexico. For other parts of the world,* $2.50. *Single copies,* 20 *cents. Remit by Express Money Order, Draft, Post Office Order or Registered Letter.*

Mailing address can be changed as often as necessary—always give old and new address, and if you subscribe in a club, state the name of the agent.

Please give prompt notice when your paper fails to reach you regularly.

Entered as second-class matter January 15, 1902, at the post office at New York, New York, under the Act of March 3, 1879.

The Multiple Throttle

Elsewhere in this issue will be found an article descriptive of a new multiple throttle valve for locomotives. The modern locomotive in use on railways in this country represents a high standard of engineering achievement and efficiency in operation of which we may be justly proud, and while this standard is high there is yet room for higher heights in many details of both design and operation.

From the earliest history of the steam locomotive those who have contributed most to its improvement seemed to have specialized or worked at it more in cycles rather than considering all parts of the complete unit. While it may be argued with much supporting evidence that this has resulted in our wonderful advancement, it suggests that in some particular features we have been a little slow to appreciate the necessity for improvement. In the matter of throttle valves, the different kinds, types, designs, etc., that have been tried seems almost too numerous to mention, including as they do the slide, gridiron, poppet, balanced in, balanced out. Then they have been located inside in steam dome and outside in nigger head in smoke box. As a result of these various experiments we finally seem to have standardized the poppet valve type located in the steam dome and to this type and practice we have with few exceptions stood committed for many years regardless of the size or capacity of engines, the steam pressure carried or other economic features that would invite attention.

It is quite true however, that the standard or conventional type of poppet valve has been much improved particularly in the matter of the auxiliary opening to provide a more easy starting engine. The location of the throttle valve in the steam dome, however, is not only wasteful but to a certain degree renders the engine less responsive to the various operating conditions in service.

To those who may look upon the outside location of the throttle as a new idea or innovation in locomotive design we may say that we have a very clear and vivid recollection of having been not alone employed in the application, but also in the rather sudden removal of outside or nigger head throttle valves on engines on one of the large western lines about 45 or 46 years ago. Those throttle valves were of the well known poppet type and were transfered from the steam dome to the nigger head in front end directly back of the smoke stack.

The initial installation was not only much less expensive than the conventional steam dome location but rendered the engine more responsive to the varying operating conditions particularly in switching movements, but obviously effected quite a saving in fuel.

As the result of an accident on line of road from which arose certain legal questions, these outside throttles were all removed or transferred back to the original steam dome location.

The employment of several small valves with graduated openings, instead of one large one, embodies a feature of improvement that has been too long overlooked. It provides means whereby the competent or careful engineer can and will start his train with less discomfort to passengers or damage to either engine or cars, while it is almost impossible for the careless or indifferent engineer to jerk or rough handle an engine and train as is too often the case with the conventional type of single throttle valve.

There are many features or parts of railway equipment, the real value of which cannot be accurately stated in money but of which we can truthfully say they possess great merit. It would appear that the apparent economic advantages of the multiple throttle cannot well be measured in terms of dollars and cents as a whole but certain features can be estimated on a given typical installation and assumed operating performance.

Twenty-five years ago only 3 to 4 per cent of total steam generated was used in the auxiliaries, while on one of our modern locomotives it is estimated at 10 to 20 per cent of the boiler output, while in extreme cases it may go as high as 25 per cent.

These auxiliaries do not as a rule use steam as efficiently as the locomotive cylinders, therefore the saving which can be effected by supplying them with superheated steam is greater on a percentage basis than in the main cylinders. Tests seem to justify an estimate of about 40 per cent saving in demand of auxiliaries by using superheated steam, which is equivalent to about 4 to 8 per cent of total fuel burned. This is one of the advantages from having the throttle located in the front end as it insures all auxiliaries being provided with superheated steam.

With the front end throttle installation the superheater is at all times filled with steam and with a minimum flow of steam through the superheater units, sufficient to protect the units from overheating, avoids the necessity for the installation of a damper and cylinder for this purpose. When viewed in its broader aspect from both an engineering and operating standpoint there are many good reasons for locating the throttle between the superheater and the cylinders.

It should be borne in mind that by the transfer of the throttle from the steam dome to the front end even with a saturated steam engine, the dry pipe then becomes a part of the boiler, and with a superheater installation the superheater at once becomes part of the boiler as it properly should be. The cubic inches of steam saved is many times greater with the latter.

In order that this feature alone may be more clearly brought out and driven home as it were we present herewith in tabulated form hypothetical cases of savings resulting from the use of outside or front end throttle with superheated installation adapted to the 4-8-2 type of locomotive in which the cubic contents of the superheater unit is 54 cubic feet or 93,312 cubic inches.

HYPOTHETICAL EXAMPLES

Kind of Service Distance 150 Miles	Estimated No. times throttle opened and closed on trip	Cubic inches of steam saved each time by outside front end throttle
1. Limited Pass.	10	933,120
2. Express Pass. 10 Stops	25	2,332,800
3. Regular Frt. 15 Stops	40	3,732,480
4. Local Frt. 30 Stops	300	27,993,600
5. Switching 10 Hours	500	46,656,000

It is assumed that on a through limited passenger train over a 150 mile division the throttle would be operated no less than 10 times, due to signals, grades, and other operating conditions. The express passenger train 25 times, regular freight 40, local freight on account of switching at stations, etc., 300 times, and a switching engine in 10 hours yard switching 500 times.

Some of these estimates may be low and others may be high, but a study may be made of the figures in connection with actual operating conditions on any particular railway. Then, by converting cubic inches or cubic feet of steam into coal or oil fuel at so much per ton of coal or barrel of oil, it will be clear at a glance just what the waste now is, and what the possibilities are for not only money saving but many other advantages.

As a result of just plain calculation, it will be seen at a glance that the saving in cubic inches of steam on just one road engine, example No. 3 above, would in 26 days of service amount to 727,833,600 cubic inches, while on one switch engine the saving might be in excess of 1,000,000,000 cubic inches of steam.

They are now in use or on order by the principal trunk lines approximately 400 of these throttles including switch, freight and passenger locomotives and it will be interesting to note results from their use both from an operating and economic standpoint.

Control of Locomotive Smoke

Locomotive smoke has seemed difficult to control, but many cities in the Middle West have attempted to solve this problem, with more encouraging results than were at first supposed possible, states the Bureau of Mines, Department of Commerce. The fact that railroads are operated uner more standardized conditions than ordinary stationary plants makes for firmer control of individual employees. In locomotive operation there is authority in the motive power department, which specializes in supervision and has all of the machinery necessary for it ready at hand. Men who work on locomotives are usually more efficient than employees of small industrial plants and respond more readily to suggestions offered in smoke-abatement programs.

In the past 10 years standardized equipment has been designed to reduce the discharge of smoke from locomotives. This equipment includes multiple tip blowers, quick-opening blower valves, and induction tubes in the sides of the fire box to supply the air necessary for complete combustion. Such equipment is simple, is easily added by ordinary boiler makers, and has been discussed in detail in the proceedings of the various railway associations. Literature on the subject is available to all railroad men.

Any locomotive properly equipped with standardized smoke-abatement devices can do its required work without making dense smoke. Experience over a number of years has shown that passenger, freight, suburban, transfer, and switching engines can operate successfully with minimum smoke production and are doing so in the Mid-d'e West. Locomotives can be and are operated in all classes of service with smoke densities below 7½ per cent, which generally brings this class of smoke down to a negligible quantity.

The cooperation of railroad executives must first be obtained in order to have proper instructions issued and disciplinary measures put into effect. Where abatement of railroad smoke has been successful, it has been customary to make the road foreman of engines responsible for the smoke performance of the engines under the master mechanic of the division. The organization for doing this is already in existence, as locomotive operation is closely supervised. The best results are obtained by making the engineer and the fireman equally responsible for smoke production; this gains the engineer's cooperation in working the engine an aiding the fireman to build up fires. When engines are equipped with blower valves, these should be installed on each side of the cab, so that the engineer or the fireman can use them when necessary.

Many railroads have found that saving resulting from this supervision more than offsets the cost to the company.

Consumption of Fuel Oil by Railways

Railroad fuel oil purchases account for approximately one-fifth of the total fuel oil marketed annually in the United States, according to the Bureau of Mines, which has conducted a survey of the subject. During 1925 (purchases totaling 70,636,559 barrels were made by railroads. Of the total purchased, 69,461,119 barrels were consumed and 1,175,440 added to the quantity in storage. Railroad stocks of fuel oil at the end of the year amounted to 13,001,647 barrels, as compared with 11,826,207 barrels at the beginning of the year. Of the total consumed, 59,627,639 barrels were burned as locomotive fuel and 9,833,480 barrels were consumed in shops, power plants, ferry boats and other non-locomotive uses.

Although each of the 147 railroads used fuel oil to some degree in their operations, its use in large quantities was limited to a few, states E. B. Swanson, economic analyst, who conducted the survey for the Bureau of Mines. Ninety-seven railroads purchased less than 50,000 barrels each during the year; 7 railroads between 50,000 and 100,000; 16 railroads between 100,000 and 500,000; 19 railroads between 500,000 and 2,000,000; 6 railroads between 2,000,000 and 5,000,000; and two railroads purchased more than 5,000,000 barrels each. The two largest purchasers were the Southern Pacific Company and the Atchison, Topeka and Santa Fe Railway Company which, with their subsidiary lines, purchased approximately one half of the total.

The use of oil as a locomotive fuel is concentrated mainly in two regions, the South Central states and California; railroads operating in these two regions having purchased 58,531,082 barrels, or 83 per cent of the 1925 total. Other centers of consumption are Oregon and Washington, supplied largely from California; the area surrounding the Wyoming oil fields; and the South Atlantic, where one railroad operates on imported oil. Oil is used as the principal locomotive fuel in both freight and passenger service in California, Texas, Arkansas and Louisiana, while in Kansas, Oklahoma, and Missouri, it is used mainly in passenger service. In the North Central states and on the

Atlantic Coast, with the exception of the one oil-burning railroad, the oil consumed is used in power plants, shops, ferry boats, firing-up of coal burning locomotives and the operating of oil-electric switching locomotives.

As the result of increased efficiency in oil burning methods, the Pacific Lines of the Southern Pacific Company have reported a saving of 2,362,129 barrels of fuel oil in freight and passenger service from January 1, 1920, to December 31, 1925. The saving from 1925, as compared with the efficiency of 1924, was 377,178 barrels. The Coast lines of the Atchison, Topeka and Santa Fe Railway Company reported a saving of 254,785 barrels during 1925, a saving which was slightly smaller than that reported for 1924. The combined saving of these two Pacific Coast lines, 631,963 barrels, in the burning of locomotive fuel exceeds the decrease of 430,233 barrels in total fuel oil burned by Class I railroad locomotives during 1925 as compared with 1924, and demonstrates that the decrease in quantity consumed was, to some extent, due to the increased efficiency in its use. The efficiency with which oil is used as a locomotive fuel has been increasing steadily.

This increasing efficiency has been accomplished through the co-operation of employees in fuel conservation; the application of modern devices, such as feed-water heaters and superheaters, to older power; purchase of new and heavier power, equipped with the latest devices; more complete loading of cars, and improvements in the roadway. Fuel conservation bureaus have been established by several railroads and careful attention is given to locomotive, shop and power plant consumption. Increasing efficiency in the burning of oil in stationary power plants and shops is comparable with that obtained in locomotives.

The comparison of the quantity of oil burned with the total fuel consumed by locomotives would indicate that the maximum point in oil burning in relation to other fuels was reached in 1924, with a slight decrease in 1925. Preliminary estimates based upon monthly reports indicate that the proportion for 1926 will be 10.5 per cent. There is at present no uniform national tendency either towards the conversion of coal burning locomotives to oil burning or the reverse, as the conditions of use vary with the relative costs of oil and coal in the particular region. One railroad operating in the Rocky Mountain region has reported that it is converting a number of coal burning locomotives to oil, while two railroads in the Middle West are converting oil burning locomotives back to coal. One large railroad operating to the Atlantic Coast has adopted oil for shop and other non-locomotive uses in replacement of anthracite coal, creating a demand for approximately 750,000 barrels annually.

Air Brake Performance

To the Editor:

If it would be possible to have the railroad air brake experts forget all the air brake instruction car theories they have learned and studied about the brake cylinder and get down to actual braking power distribution as it is in actual service and the piston travel and cylinder pressures as they are developed with the initial seven or eight pound brake pipe reduction in actual service, using an air gauge on cylinder, auxiliary and train line and note the initial pressures standing, and at several kinds of slow speeds as well as over rough track while making stops at high and low speeds, we will be encouraged to believe that they would arrive at such an understanding of the brake.

One of the most stupid recommendations of air brake men is the full service application of the brakes for terminal and round-house tests. The above test does not furnish any reliable information, except that the brakes operate. What is needed most of all and a thousand times more important than the full service application test, is demonstration of the brakes at terminals, that will show the brake is producing a low cylinder pressure for a light brake pipe reduction. Let that fact soak in very deep, and until it does find room to lodge in the thinking apparatus of air brake men on American railroads, there isn't much hopes of smooth handled air braked trains.

Another expression that often is heard from air brake men in speaking of the engineer handling the train rough at some particular place, "he made smooth stops 99 per cent of the time and the last one was very rough." They never know what is taking place in the brake cylinder for any kind of brake pipe reduction. They never know anything about the proper distribution of the braking power that the cylinder develops. They do not know the effects of different speeds for the same brake pipe reduction. They do not know the effect that different track conditions have on the same brake pipe reduction. And, furthermore, they do not know that the braking power can be equally distributed and the piston travel adjusted so it will be impossible to shock the train, except that caused by bunch slack in the drawheads or a poor friction draft gear.

The brake is very simple in its operations and it performs its function 95 per cent better than any of the human or other elements that go to make up the railroad family. All the brake needs is proper care and an understanding of how to adjust it so it will do just what it was designed to do, namely, "produce a low cylinder pressure for a light brake pipe reduction." For instance, the writer recently readjusted a brake on a car that had 4-in. piston travel for a 10-lb. brake pipe reduction. The cars ahead and behind this car had nearly 7-in. piston travel for the same brake pipe reduction and there wasn't more than ⅜-in. difference in the piston travel of the three cars when a full service application was made. The false piston travel doesn't all develop on some cars with an 8 or 10-pound brake pipe reduction. It's scarcely necessary to mention that the above mentioned short piston travel car was raising all kinds of hell every time a stop was made at slow speeds. Check up your false piston travel and do it now. Just recently it has been discovered that a steam gauge on the steam chest and cylinder shows the engineer what he is doing. Why not put a gauge on the brake cylinder and train line, back in the train and lead the air brake men to it?

Why expect the brake or engineer to produce smooth results when some trucks and wheels have from 100 to 1000 per cent more braking power than other wheels and trucks under the same car and other cars in the same train? And, mind you, the piston travel may be perfectly equal on all cars for a 20-lb. brake pipe reduction. The unequal wear and heat shown on the brake shoes will prove this statement. Besides, rapping the shoes with a hammer when a light brake pipe reduction is made will prove it. Twenty years ago we found shoes that were loose after a 20-lb. brake pipe reduction and each cylinder was adjusted to 6-in. piston travel.

The shocks come with the initial pressure if unequal in the cylinder or not properly distributed to the wheels. Too much slack in the drawheads and a pile of junk for a friction draft gear on steel cars greatly increase the shocks. It's just as cheap to adjust the brake so the pressure will be low for a light brake pipe reduction and distribute the braking power equally to all wheels as it is to do it all wrong and cause thousands of dollars worth of damage.

Interested Reader.

Operating Passenger Trains Without the Use of Angle Cocks[*]

Preliminary and General Service Tests on the Pennsylvania in Co-operation with the New York Central Demonstrates its Practicability

By W. H. Sitterly, Gen. Car Inspector, Pennsylvania Railroad

Several years ago the management of the Pennsylvania became satisfied that the angle cock could be eliminated from passenger equipment without detriment to the service, in so far as increasing time required in switching passenger trains is concerned, and outlined a test at Harrisburg, Pa., where a large percentage of the trains operating through that point are broken up. The test was satisfactory, as it develoved that no more time was required to switch a train without the use of angle cocks than it did with them. Recently the same test was made simultaneously at all passenger terminals on the Pennsylvania Railroad with about the same success as was obtained at the first test at Harrisburg.

The Train Brake and Signal Committee of the American Railway Association, Mechanical Division, became interested and conducted a series of tests at terminals on various railroads in the United States.

Early in August our management decided to eliminate the angle cock by locking the handle in the open position, the brake pipe being closed at the rear of the train by attaching the hose to the dummy coupling provided for that purpose. The date set for this operation to begin was 12:01 A. M., October 1, instructions being given that all angle cocks should be locked in the open position within a period of 72 hours after that date. All railroads with which passenger equipment cars are interchanged were notified of the effective date of locking angle cocks on all passenger equipment cars. On the Northern division the New York Central Railroad heartily co-operated with us in this operation, both at Exchange Street Station, Buffalo, and at Erie, Pa.

Before going into the supplementary instructions to train service employes in the handling of trains of cars with the angle cock open, locked in the open position, I might say or illustrate to you that the operation was a very simple one. This lock was stamped out of sheet steel. The small orifice is intended to go up over the angle cock handle to keep it from being raised by train service employes, as you notice, in locking the angle cock handle, it has to be raised before it can be placed in the closed position. The large orifice, after this clamp was placed over the handle of an angle cock, registered with the opening in the angle cock, then the hose, or this hose extension nipple with which you are all familiar, used with a type "D" coupler to move the hose down where it can be easily unscrewed with a Stillson wrench. This absolutely locks the angle cock in the open position. Presumably instructions will be issued at some time in the near future that when our passenger train equipment goes through the shop for repairs, the angle cocks are to be removed as there will be no loss, because you know that all angle cocks used on passenger cars are bushed from 1¼ inches to an inch. The only thing necessary is to remove the bushing which will make it available for freight equipment cars. The operation for closing the brake pipe at the end of the train is by coupling the dummy coupler into the hose coupling. That is the only interruption from the head end of the train to the rear end.

I was present at the tests at Harrisburg and we operated for 24 hours with the use of angle cocks on trains that were broken up at that station. The following 24 hours we operated with the angle cock locked, open, and then used a dummy to blank the brake pipe wherever it was necessary in the course of switching.

Supplementary instructions to the Air Brake and Train Air Signal Instruction Book 99-A-1 for attaching and detaching locomotives or cars in passenger train service without the use of brake pipe angle cock, for the guidance of employes who are engaged in the maintenance or operation of locomotives or cars in passenger train service, were issued under date of August 9, 1926, and are as follows:

Attaching and Detaching Locomotives or Cars in Passenger Train Service Without the Use of Brake Pipe Angle Cocks

The angle cock handles on all locomotive tenders and cars used in passenger train service will be securely clamped in the Open position on September 1, 1926, except those on shifting locomotives. The brake pipe stop cocks on the front end of all locomotives will not be modified and may be used as at present.

A. When Trains Are Not Broken Up and Change of Road Locomotive Is Only Required

1. ARRIVING TRAIN: After stop is made, engineman will make a service brake application of 25 pounds, after which he will place the brake valve in Emergency position, and leave it there until a signal is received for a release. The air brake hose shall then be parted between locomotive tender and car. The air brake hose coupler on the locomotive tender will then be placed in the Dummy Coupling, after which a signal should be given to the engineman for a release of the brake. The engine will be cut off in the usual way.

2. DEPARTING TRAIN: After the road engine is coupled to the train, the engineman will make a service brake application of 25 pounds, after which he will place the brake valve in Emergency position, and leave it there until a signal is received for a release. The Inspector will then remove the hose from the Dummy Coupling on the locomotive tender, and unite it with the hose coupler on the first car in the train, and then signal the engineman to release the brake, except in cases where a change is to be made in the make-up of the train by a shifting locomotive from the rear. The engineman in charge of the road locomotive must not release the train brakes until the shifting has been completed. The usual air brake tests will then be made after the brake system has been charged to at least 70 pounds.

B. When Trains Are Broken Up and No Change of Road Locomotives

1. ARRIVING TRAIN: After stop is made, engineman will make a service brake application of 25 pounds, after which he will place the brake valve in Emergency position,

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[*] *A paper read before the Central Railway Club.*

and leave it there until all shifting movements have been completed. The engine and tender brakes may be released, if necessary, by the use of the independent brake valve.

2. Switching Road Train—Either Setting Off or Adding Cars: All switching of cars should be controlled by the air brake. The air brake hose on the rear of the rear car (furthermost from the locomotive) in draft shall be coupled to either the Dummy Coupling on the car or the Back Up Hose. After the shifting engine has coupled to the train and the hose coupler united, the trainman will open the angle or stop cock on the shifting locomotive to release the air brakes on the cars in the train.

When setting off or picking up cars in a train that is being shifted, it will be necessary for the engineman on the shifting locomotive to make a service brake application of 25 pounds, after which he will place the brake valve in Emergency and leave it there until he receives a signal for a release of the brakes. The trainmen or inspectors will separate the air brake hose couplers where separation is to be made in the train, and couple them to the Dummy Couplings or standard Back-Up Hose before signaling for a release of the brakes.

When shifting trains without the use of angle cocks, it will be necessary to deplete the brake pipe pressure before any separation can be made which should be done by making a service application of 25 pounds, after which the brake valve should be placed in Emergency position until a signal is received to release the brakes. Dummy Couplings which are standard for all passenger locomotives and cars, or the standard Back-Up Hose and Alarm Whistle must be used for closing communication between the brake pipe and atmosphere when making train movements.

The speed of trains while shifting, should be controlled by the air brake, and in no case should shifting or road movements be made unless the brake system is charged to at least 70 pounds.

It was my privilege to witness the operation at our passenger car storage yard on the morning of October 1. You all understand that our trains arrive and depart from the New York Central station at Buffalo, making it necessary to back them into the station. The movement of the train, so far as the brakes are concerned, is controlled by a pilot on the rear end. Our instructions to enginemen are to lap their brake valve whenever they are approaching a tower or a point where a stop is liable to be made, thereby placing in the hands of the pilot an opportunity to make whatever reduction in the brake pipe he desires to make to stop without having the air blowing in through from the main reservoir into the brake pipe as fast as he is trying to draw it down. On our trains I noticed on that particular morning the pilot came down through the yard and hung his back-up hose on the gate of the Pullman car after which he got up on the platform and followed out bulletin issued by our Superintendent. Six blasts of the communicating signal should be given to the engineman to deplete the brake pipe pressure so that he could couple up the back-up hose. This pilot did so. Immediately after the brake pipe was depleted he stepped down, connected up his back-up hose, then gave the engineman a signal to rlease the brakes. After that was done the pilot followed further instructions that he must make a test of the brakes before he leaves the empty car yard, to know that he has control of the brakes from the rear end of the train, and after he was satisfied that the brake system was recharged on those cars, he gave the engineman the usual signal to lap his brake valve. After the brake valve was lapped he immediately applied the brakes by the use of the back-up hose, got down on the ground, went over the train as far as the engine to see that all brakes were applied, came back and gave the engineman a signal to release the brake.

I do not know of any cases where we had any delays to our passenger trains. I was on a train the other day coming in from Emporium, picked up a milk car at Lime Lake, came down there and made a service application, depleted the brake pipe, went in, picked up the car, came out and got away in the same time as they had when I rode a train when they were using the angle cock—they did not have two angle cocks to close.

For the benefit of the car men here, I may state that we have found a number of dummy couplings leaking. We corrected this by making a socket to fit over the dummy coupling, applying to it a piece of emery cloth and rotating this over the face of the dummy coupling a few times, cleaning the surface, so that it was absolutely tight.

Railroad Efficiency in 1926 Exceeded All Previous Years

A Review Prepared by the American Railway Association

With an efficiency never before equaled, the railroads of this country in 1926 handled the greatest freight traffic ever offered to them by the shippers of the United States.

Operating as smoothly as a well lubricated piece of mechanism, the great transportation machine of this country has moved this record volume of traffic without transportation tie-ups, congestion or car shortage except in certain isolated instances of a temporary nature.

Freight cars have been promptly provided for shippers, and freight has been moved with a dispatch unequalled in previous years. It is difficult to estimate in dollars what this adequate and dependable service has meant in money to the shippers of this country, but there is no disputting the fact that it has resulted in substantial savings. Because of this prompt and efficient service, the railroads have contributed largely to the placing of business on a stable basis and have enabled industry to operate on smaller stocks than has ever before been possible.

One of the outstanding reasons for the efficient and dependable service which the railroads rendered in 1926 was the large expenditures for capital improvements that have been made in recent years in order to provide more adequate transportation and to increase the economy and efficiency of operation. Since 1920, capital expenditures of the railroads have amounted to nearly $5,200,000,000, of which $875,000,000 was spent in 1926. In the latter year, however, expenditures authorized for capital improvements amounted to $1,325,000,000 of which authorizations approximating $450,000,000 will be carried over to 1927 for completion.

Capital expenditures in 1926 for equipment, which includes locomotives and cars, amounted to approximately $380,000,000, compared with $338,000,000 in 1925. Capital expenditures for roadway and structures, additional track, heavier rails, additional ballast, shops and engine houses, including machinery and tools, amounted to $495,000,000 compared with $410,000,000 the preceding year.

Greater cooperation on the part of the shippers, both individually and collectively, and also through the various Shippers' Regional Advisory Boards now located in all parts of the country has also been of material assistance to the railroads in successfully meeting the record traffic which the carriers have been called upon to handle in 1926. With the formation of a Shippers' Regional Advisory Board in the Pittsburgh District in November, the organization of these Boards for the entire country was completed. Fourteen Boards are now in existence with a membership of approximately 15,000 representatives of virtually every industry to be found in this country.

More Ton-Miles of Freight

Not only did the number of cars loaded with revenue freight in 1926 exceed all previous records but also the volume of freight traffic as measured in net ton-miles, which is the number of tons of freight multiplied by the distance carried. Reports show that the volume of freight traffic for the first ten months in 1926 amounted to 405,131,386,000 net ton-miles which exceeded by 19,107,698,000 net ton-miles or 4.9 per cent the best previous record, which was that for the corresponding period in 1923. On the basis of the showing for the first ten months, it is estimated that the total for the year will amount to 488,000,000,000 net ton-miles, an increase of 32,000,000 000 or seven per cent over the best previous year, which was in 1923.

The greatest freight traffic for any one month on record was carried by the railroads in October when it amounted to 48,273,089,000 net ton-miles. This exceeded by 3,944,912,000 net ton-miles or 8.9 per cent the previous high record made in September, 1926, while it also exceeded by 11.9 per cent the best previous record prior to 1926, which was made in October 1924.

Fuel Economy

Due to greater economy and efficiency in the use of fuel, brought about not only through the use of improved locomotives but also educational campaigns among employes, the railroads in 1926 established a new low record in the quantity of fuel used. For the first ten months, an average of 134 pounds of coal was required to haul a thousand tons of freight and equipment one mile, the lowest average ever attained.

Equipment Condition

The railroads in 1926 had fewer locomotives and freight cars in need of repair than at any time in recent years, despite the record traffic which they were called upon to move practically throughout the entire year.

The railroads in the first eleven months of 1926 installed in service 99,365 freight cars. Car ownership on December 1 was approximately 124,095 cars or 5.4 per cent greater than on June 1, 1923, and the average carrying capacity per car owned increased 2.1 tons per car or 4.9 per cent.

In the first eleven months of 1926, there were also placed in service 2,193 locomotives. The number of locomotives owned on December 1 was a decrease of 2,186 locomotives or 3.4 per cent compared with June 1, 1923, but the average tractive power increased nine per cent.

Despite the decrease in the number of locomotives owned and the heavy freight movement which characterized the year, the railroads have at no time had less than 3,800 serviceable locomotives stored in good repair which they have not found necessary to place in service.

Records in Freight Movement

Due to the faster loading and unloading of freight cars as well as the elimination of many delays in handling, freight shipments were moved with the greatest dispatch in 1926 that has ever been attained, the average movement per freight car per day in October having been 34.3 miles. This exceeded by 1.6 miles the previous record for any one month, established in September, 1926, for which the average was 32.7 miles. The average for the first ten months in 1926 was 30.4 miles compared with 28.2 miles in 1925.

The average load per freight car, for the first ten months in 1926, was 27.2 tons. This was greater than in 1922, 1924 and 1925, but fell below 1921 and 1923. Failure of the average load per car to show a larger increase in view of the heavy traffic which the railroads moved was due in part to the larger proportion of the lighter loading commodities carried in 1926. Efforts are being made, however, to educate the shippers of the country to the necessity for loading cars more nearly to capacity.

A new high record in the average load of freight per train for any one month was established in October, when it amounted to 829 tons. This was an increase of 33 tons over the best previous record prior to 1926, made in August, 1925.

A new record was also made in the average speed of freight trains for the first ten months in 1926 when an average of 12 miles an hour was attained. The average number of freight cars per train for the first ten months of 1926 was 45.3, which was greater than for any previous year.

The average number of miles each freight locomotive traveled per day was 60.6 miles, an increase of more than twelve per cent above the average for the previous five years while a new high record was also established in ton-miles per train hour

Passenger traffic in the first nine months of 1926 showed a decrease of eight-tenths per cent under the corresponding period in 1925.

Taxes About $400,000,000

The railroads of 1926 were called upon to pay more taxes to local, state and federal governments than ever before, their tax bill for the first ten months this year having been $329,388,745 an increase of 39.9 per cent over 1921. On the basis of actual reports for the first ten months this year and an estimate as to what taxes they will pay in the last two months, it is estimated that the tax bill of the rail carriers for the entire year will be approximately $400,000,000, an average of more than $1,100,000 per day, and an increase for the year of $36,000,000 over the total tax bill for 1925.

Net Operating Income

The net operating income of the Class I railroads in 1926 was approximately $1,250,000,000 or a return of 5.23 per cent on their property investment. This estimate is based on complete reports for the first ten months which showed a net railway operating income of $1,035,475,630, which was at the annual rate of return of 5.25 per cent on their property investment, and an estimate made by the Bureau of Railway Economics as to earnings in November and December Railway business and earnings fluctuate from year to year. Only the showing of results over a period of years can indicate the real trend of railway returns. The rate of return on property investment for the five years ending with 1926 has averaged 4.52 per cent per year. The rate of return on the basis of railway returns. The rate of return on property in-

1920	0.09%	1924	4.33
1921	2.92	1925	4.80
1922	3.61	1926	5.23
1923	4.48		

Handy Railway Devices

Loading Cinders from Locomotive Ash Pits

The device shown in the accompanying illustration facilitates the removal of cinders from small locomotive ash pits. A pit or excavation is dug beneath the track and lined with concrete walls. The excavation extends a few feet out beside the track. A small dump car runs on a diagonal track, the elevated end of which terminates over the loading track and the lower end of which passes into the excavation alongside the track.

The dump car is made up of two small trucks with flanged wheels that run on the diagonal track which is made of discarded rails. The rectangular body of the car, made of sheet metal, holds the discharge of four or five locomotives. One half of the bottom or floor of the car body is loose and hinged at the lower corner with heavy strap hinges. Near the center of the car bottom and attached to the drop lid or shutter is another wheel that runs on a center rail between the two forming the main part of the track. This center rail extends to a few inches past the edge of the gondola cars into which the cinders are loaded, where it curves downward. The car is lowered into the pit until several engines have been cleaned, the cinders dropping into it between the rails, space having been provided for them to drop through by omitting two or three cross ties and supporting the rails with the concrete walls of the pit. A gasoline engine drives a drum on which a cable winds on the opposite side of the gondola being loaded, by which the cinder car is drawn up the diagonal track until the wheel under the center comes to the downward curve in the center rail, where it rolls over the curve and drops down, allowing the hinged half of the car bottom to drop, releasing the load into the gondola. The hinged half of the bottom is the half next to the cinder pit track, and because of the slanting position of the other half of the bottom, the cinders slide out without attention.

Loading Cinders from Locomotive Ash Pits

Handy Rack for Coupler Knuckles

Considerable time and effort were being expended in a railway repair shop in locating any certain style or type of knuckle for replacing broken or lost ones used to make couplings between cars, on account of the fact that the supply was kept unassorted or heaped together on the room floor where the stock was kept. Often a dozen knuckles had to be turned about before finding the particular type or make sought. In order to eliminate this inconvenience, the handy rack shown in the photograph herewith was built.

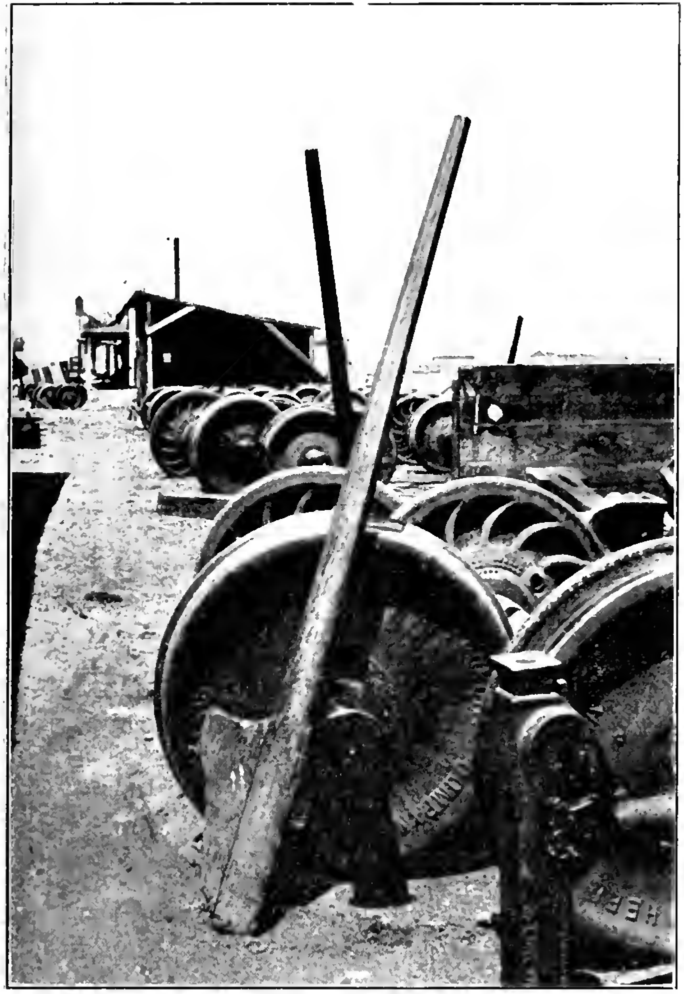
It is made up of several pieces of 4x4 inch lumber standing in two rows 4 feet apart at their bases and each row inclined inward at the top and spiked to the side of a piece of 2x8 inch stock placed horizontally between their top ends. The upright rack pieces are 5 feet long and their upper ends are bevelled so as to fit against the side of the ridge piece at the top supported on its edge. Their lower ends are also bevelled and stand on other horizontal pieces on the floor beside an assembly track. Another piece of this lumber 5 inches wide is attached on its edge on top of the ridge piece and has readings over the space between each of the rack pieces denoting the style, kind or type of knuckle to be found below the reading. The 4x4 inch rack pieces are placed 4 inches apart and each different style or type of knuckle is stacked in a separate vertical slot formed by the rack pieces, by inserting the drop pin latch and king pin bearing between the upright pieces, turning the curve of the knuckle downward, which causes them to somewhat nest together, making it possible to place more pieces in each slot. Instead of grappling several minutes through a heap of knuckles dumped on a floor, when a particular kind is needed it is only necessary to walk up to the rack and note the reading on top and pick up only one, the kind desired. The reading can be observed while walking up to the rack, and the particular knuckle wanted picked up on arrival.

Handy Rack for Coupler Knuckles

Special Jack Facilitates Handling Railway Car Trucks

The task of transferring the wheels and axle of railway car trucks about a yard, over rails in tracks, etc., is difficult without the aid of some device for delivering more power to them than direct muscular power. The accompanying photograph shows a handy jack stick that is very helpful in this task.

A piece of 4x4 inch hardwood 5 feet long is turned or trimmed down at one end to a good hand grip, beginning about 18 or 20 inches from one end of the piece. A handle resembling the handle used in peavies or cant hooks is thus formed, except one end is square down about 20 inches. Bolted onto this square portion is a triangular shaped block made also of hardwood, with the broad end upward. This block is made from a piece of material 4 inches thick. The upper end that thus forms a shoulder is rounded out so that an axle will not so readily roll off it when its weight is lifted on the shoulder. When trucks are to be moved about the yard, over rail, etc., the lower end of this jack is passed under the axle with the handle in a diagonal position and the shoulder upward or turned upward after it is passed under the axle, so that when the handle is raised upward the axle will rest on this shoulder. Then the handle is brought upward and over forward, by one or two men. Besides the forward pressure of the handle against the axle, as this shoulder rises upward the weight of one end of the axle is lifted on it. The shoulder should be 3 inches higher than the under side of the axle when the jack is standing vertically beside it. Thus the wheels are lifted over the rails when necessary to pass them over it, and it is also handy in throwng one end of the axle forward when a pair of trucks are being transferred from one place to another by rolling them and it becomes necessary to throw one end forward to change the course. Although this handle or jack is made up of two different pieces when it is made, thus eliminating the use of bolts thus, as the whole device could be made of a solid pieces of material, working out a shoulder on one side of the pieces when it is made, thus eliminatng the use of bolts for bolting on the triangular piece. However, it is a handy tool, and greatly appreciated by car repairmen, etc.



Special Jack Facilitates Handling Railway Car Trucks

Reading Company Exhibits Automatic Train Control

On January 6, the Reading Company gave demonstration of the Union 3-speed continuous automatic induction train control which has now been in use on all trains of the line since April, 1925. The test was on the Atlantic City division near Winslow Junction, N. J., twenty-five miles from Philadelphia.

E. D. Osterhout, passenger traffic manager, and other officers of the road, a large number of technical men and others, were taken by a special train from Camden, N. J., and various stops and other operations were carried out for the benefit of the officers and men. Before the departure from Camden, P. S. Lewis, superintendent, gave a short lecture with blackboard illustrations to acquaint them with some of the main principles of the system, duplicates of the cab indicator lights and gages being set up in the car next behind the locomotive.

The principal tests were one near Clementon to show the behavior of the automatic stop when the engineman kept hands off, as though he were dead, and one when the speed of the train was brought up to a rate above 85 miles an hour and automatic application of the brakes took place, bringing the train to a stop, the apparatus being adjusted to prevent any speed higher than 85 miles per hour. This is the maximum limit on this division, as the line is 55 miles long with few curves.

The number of locomotives on this division equipped with automatic train control is 57 and 68,088 trains have been run with automatic train control in service without a failure, which mean, of course, a dangerous failure. The trains traveled around 2,781,530 miles. The medium speed limit is 40 miles and the low-speed 20 miles an hour. The company's expenditures for the installation and the perfection of this system have aggregated upwards of $750,000, equal to about $13,500 per mile or road.

Improved Methods in Handling Tickets at the Pennsylvania Station in New York

At the Pennsylvania station, Seventh Avenue, New York City, the space devoted to ticket selling has been enlarged about 30 per cent and passengers now buy both railroad and sleeping car tickets at the same window.

Each ticket seller is also equipped with an individual ticket case (which includes his money drawer) so that when he goes off duty, he can lock up his tickets and money and roll the case back, making room for the man who takes his place.

The Pullman diagram room, where all sleeping and parlor car space is allotted, has been trebled in size and its wire facilities doubled. The number of operators here has been increased and this room now takes care of about 10,000 telephone transactions daily. This room also has its own telegraph office, employing four operators for communication with places at a greater distance than is covered by ordinary telephone communication. An average of 420 Pullman cars now depart from the Pennsylvania station every 24 hours.

The diagrams of Pullman cars are sent to the station platform through a pneumatic tube about eight minutes before the departure of the train; and before being sent, each diagram is reproduced by photostat process. For example, the ten cards for a train of ten Pullman cars are spread out on a sheet and photographed; and this photostat, about 30 in. square, is filed as a record of the transactions of the office for that train.

Lubricants and Lubrication*

By Mr. J. Duguid, Engineer of Tests, Galena Signal Oil Co.

Previous to 1859 commercial lubricants were derived mostly from vegetable and animal oils, and from a small amount of mineral oil obtained from the distillation of shale. However, as far back as 1797 crude mineral petroleum was found and skimmed from the waters of Oil Creek, near Titusville, Pa., and is reputed to have sold for as high as $16.00 per gallon. But the real production of mineral oils began when in 1859 Col. Edwin L. Drake drilled the first oil well on the banks of Oil Creek. In that year 1873 barrels of crude petroleum were produced and sold at an average price of $20.00 per barrel. A monument in memory of Colonel Drake—the real pioneer of the oil industry—has been erected and now stands near the locality of his discovery well.

At the close of the year 1924 the average monthly production of crude oil for the year had been about 59,000,000 barrels, or nearly 2½ billion gallons per month, whereas in 1918 the total production was about 30,000,000 barrels per month and less than half our present average production. This will give some idea of the very largely increased production developed in the past few years.

The total crude mineral petroleum produced since 1859 in the United States is a little less than eight billion barrels of 42 gallons each. Various prominent geologists have estimated our total oil resources at from twelve to fourteen billion barrels. More than 600,000 wells have been drilled in the United States and the average cost per well has been estimated at about $20,000, which is probably a little high for a general average. In 1923 more than 24,000 wells were drilled, and in 1924, nearly 22,000 wells, but about 25 per cent of the latter turned out to be dry holes. The percentage of dry holes is increasing each year, which tends to bear out the geologists' estimates of diminishing supply.

The prices of the various crudes range from about 50 cents to $3.40 a barrel, the latter being the posted price for Pennsylvania crude at the present time.

Of the total crude produced in the United States during the year 1924, about 4 per cent, or more than one billion gallons, was converted into lubricants of various kinds. Of this amount approximately one-third was exported, the remaining two-thirds going to domestic consumption and stocks. The amount in storage today is somewhat over 250 million gallons. The foregoing figures give a general idea of the developments of the industry and its importance at the present time.

Early Work in Lubrication

Down to the year 1875 the question of lubrication was not given much attention from a scientific engineering standpoint. However, about 50 years previous to that time it had become the subject of much speculation and discussion, and after considerable experimental research Morin advanced certain theories on which he established the following three laws of friction:

1. The friction between two bodies is directly proportional to the pressure.
2. The amount of friction (pressure being the same) is independent of the areas in contact.
3. The friction is independent of the velocity, although static friction is greater than the friction of motion.

About 1875, however, these laws or theories were found to be almost entirely erroneous and it was proven that the friction between two bodies is not directly proportional to the area in contact, and that the friction is dependent upon the area of contact, and that the friction is also dependent upon the velocity, but that in neither case are they in direct proportion. Notwithstanding all the technical data that have become available since that time on friction and lubrication, it is evident that we are to a degree still groping in the dark regarding these engineering subjects. The various kinds of metals used for bearings, their mechanical construction, the various kinds of lubricants and the methods of applying them—all of these as related to bearings used for the same purpose, show a lack of engineering standards as well as of definite knowledge of the subject.

Even at the present time, with all the modern developments of engineering science, very few users of lubricants employ engineers whose duty it is to look into the question of the efficiency of the lubricants they buy, the cheapest oils usually being favored without regard to the total amount used or to the losses that occur through high friction and wear.

It is only common-sense that large users of lubricants should require the oil manufacturer to demonstrate the efficiency of the lubricants he supplies. If this were always done it would soon become apparent that price, appearance and viscosity of oils provide a very unreliable basis for selection. The factor of viscosity is mentioned particularly because this can be so easily faked. Very light oils of no particular lubricating value or viscosity can be brought up to a very high viscosity and fine appearance by compounding them with either a small proportion of degras oil or aluminum soap, and such oils, when placed in cans bearing fancy colored and extravagantly worded labels, are very attractive to the uninitiated.

It is evident that at the present time the efficiency of lubricants—as well as the efficiency of other materials—is being more studied than in the past. This has been brought about mainly through increased costs of labor and material, and the modern manufacturer must make close inquiry into actual efficiencies in order to maintain his works in profitable operation.

A few years ago railroads generally did not give much attention to the efficiency of the individual locomotive—they kept up to the requirements of tractive power by building larger ones. But it is quite apparent that the locomotive has now about reached its limit for size, and the live question is to make each unit more efficient. One of the results of this is that we now find locomotives equipped with feedwater heaters—who would have ventured suggesting such cumbersome apparatus to the railroad official a few years ago?—superheaters, and many other auxiliary devices. In fact, progressive railroad men are now willing to try out any device that gives reasonable promise of even a small percentage of increase in locomotive efficiency. In my opinion, the next important problem that will receive close attention is the friction of the lubricated parts, as here is surely a fertile field for investigation and improvement.

The efficiency of a machine is measured by dividing the amount of useful work performed by the gross work of the machine. Experience has shown that friction is the principal cause of loss of energy, and therefore loss of work in machinery; also that waste energy can be reduced to a minimum by installing the proper kind of rubbing surfaces and by the use of the best lubricants.

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* Abstract from a Paper Read Before the Canadian Railway Club.

The object of lubrication is both to reduce friction and to prevent excessive temperatures. The true value of the lubricant depends upon its efficiency in reducing friction, its durability under wear and adverse mechanical conditions, its freedom from acids and grit, from liability to gum, and its physical condition when subjected to change in temperature. It should always be borne in mind that as the temperature increases the lubricating power of the lubricant decreases, and it should not be assumed that a hot bearing may be cooled by increasing the quantity of the lubricant. The cause of the heating must be removed.

Tests that usually interest oil users are those covering specific gravity and viscosity, but from a practical lubricating standpoint these tests as ordinarily carried on in commercial practice count for little, other than for classifying the oils. They do not furnish any absolute data for determining the real lubricating value of the oil, although enabling certain conclusions (sometimes wrong) to be drawn on the subject. The viscosity of lubricating oils is ordinarily taken at 100 or 130 deg. Fahr., and it is therefore not known what the viscosity of the oil is when the film is passing under the highest point of load on the bearing. These are important factors of characteristics in various lubricants that greatly affect their lubricating value which cannot be determined by ordinary gravity or viscosity tests unless the latter are carried out under extreme pressures and temperatures such as are not practical for commercial testing. One important feature called by some authorities "oiliness of the lubricant" cannot be ascertained without special research tests.

The Theory of Lubrication

The theory of lubrication is altogether too technical to be set forth in a paper of this kind, and therefore only a few of the propositions that are readily understood and perhaps of the most interest to the ordinary oil user will be referred to. Some of these are, roughly, as follows: That irrespective of how smooth a journal and bearing may appear and no matter what the amount of so-called finish that may be applied to them, there are still projections presented on these apparently smooth surfaces and these projections on the journal and bearing will interlock and abrade when set in motion if not separated by a lubricating film; that one oil film adheres to the bearing and one to the journal, and that there is no slipping of these films on the metals; that the films slide on each other and the metals are kept wholly separated, and therefore with this condition there can be no wear of the metal parts; that the oil film is in the shape of an eccentric ring, the thinnest section being a few degrees past the center of the bearing load in the direction of motion of the journal; that the pressure of the oil film varies, being greatest (about twice the pressure per square inch as compared with the load on the bearing) at a point a few degrees past the center of the bearing load, and that the sum of the pressures on the film about equals the total load on the bearing; that the temperature of the oil film passing under the area of highest pressure is not known; that the resistance of one oil film to sliding on the other is the frictional load, and that the heat generated by such resistance causes the temperature; that the thickness of the oil film under the load area varies from about 0.0002 in. to .003 in. in thickness, depending on the class of bearing, velocity, elastic deformation; that the oil film is heated while passing under the load area until the evaporating temperature is reached and part of the film becomes a gas and escapes to the atmosphere carrying with it the frictional heat it has absorbed; that this transformation takes place in every bearing but on so small a scale that it is imperceptible; that there is a well defined line on the load area where this invisible transformation from the liquid to the gaseous state takes place; that if from any neglect or lack of lubrication the bearing becomes overheated the few particles of oil vaporize too fast, and become decomposed, and the vapors have a burning smell, and this becomes perceptible to our sense of sight and smell.

In bearing lubrication it is evident that in a majority of cases the lubricating film is very thin, and that with the ordinary mechanical methods of applying the lubricant there is difficulty in feeding the oil to the bearing so as to maintain a uniform film. It is also evident that the performance or condition of the oil film under the maximum pressures of load are still in the research stage, and that infinitesimal differences not observable by the naked eye on the surface of journals and bearings of the same class affect the oil film and make radical differences in running temperatures.

It has been demonstrated that when a good oil film is established it does not wear out rapidly and will last for an almost incredible period of time, provided its frictional temperature is normal. If the temperature is increased above normal either by friction or some foreign heating agent, the life of the film will be very materially shortened and its duration will have a closer relation to temperature than to the lubricated surface rubbed over.

Kinds of Lubricants

Practically all commercial lubricating oils are compounded; that is, they are mixed with other lubricants for the purpose of obtaining the viscosity of body, oiliness, and emulsifying or non-emulsifying properties that will make each lubricant best suited for the purpose it is to be used.

It is sometimes assumed by oil users that none but mineral oils are needed in the compounding of oils. This is not the case, as both vegetable and animal oils such as castor, rape, tallow, lard neatsfoot, whale, wool oil and fish oil are all used in the compounding of various kinds of lubricating oils. In the greases there are also used such solid lubricants as graphite talc, and mica, while leads are used both in oils and greases. In general, lubricating oils may be divided into seven classes: namely, unfiltered cylinder oils, filtered cylinder oils, red oils, pale oils, neutral oils, white oils and black oils.

There is no complete or accurate data showing in detail the consumption of lubricating oils and greases.

The railroads of Canada and the United States use for locomotives about 25 million gallons per year, for freight cars about 5½ million gallons, and for passenger cars about 1½ million gallons.

The average cost for these per 1000 miles is approximately $4.50 for locomotives, 4 cents for freight and 6 cents for passenger cars.

Automobiles are the largest users of lubricants, and their yearly consumption is around 90 million gallons at the present time.

These few figures give some idea of the requirements for lubricating oils, but only accounts for a small percentage of the production, and there are so many varied uses for lubricants that it would be an almost endless task to enumerate them. It is evident, however, that a large gallonage is wasted by careless handling, excess and faulty application, and improper mechanical conditions. It seems that few users realize that it requires only a comparatively small amount of suitable oil to lubricate a rubbing surface. The average user seems to work on the theory "that if one pint of oil a day will lubricate a machine efficiently, then two pints per day will lubricate it twice as efficiently." Or, judging from observation, some seem to think that if oil is plastered all over the machine it has then—but not until then—the proper appearance of efficient oiling. These really seem to be the standard gauge for application in only too many cases.

Surface Area Requiring Lubrication on Locomotives

The lubricated surface area on the old small 17x24 four-wheel type was 19,000 square inches, 4400 of this area being in the cylinders, valves, and the total lubricated surface rubbed over per mile with a 63-in. wheel was 6,645,000 square inches.

With the present Mountain type with 28x30 cylinders the total lubricated surface is 55,350 square inches, 10,200 of this being in the cylinders, valves, and the total surface rubbed over per mile is approximately 13,700,000 square inches or over 2 acres.

The lubicated surface on a 2-10-10-2 type heavy Mallet with 28x44x32 cylinders is 93,400 square inches, 25,000 of this being in the cylinders, valves, and the total surface rubbed over per mile is 34,600,000 square inches, or over 5½ acres.

The average lubricated surface for all engines (not including the old four-wheel type or the Mallet type) is 37,780 square inches, and the surface rubbed over per mile is 11,110,000 square inches.

If then the average miles per pound or pint is 12 then the surface rubbed over per pound of lubricant is 133 million square inches, or approximately 300 square inches per milogram of lubricant.

On feight cars the average surface rubbed over per mile is 884,500 square inches, and as they use an average of about 1¼ pounds of oil per 1000 miles the surface rubbed over per pound of lubricant is approximately 707 million square inches, or about 1500 square inches per milogram.

On passenger cars the average lubricated surface rubbed over per mile is about 1,100,000 square inches, and the oil consumption is about 2 pounds or pints per 1,000 miles, this is 550 million square inches of rubbed over surface per pound of oil, or 1200 square inches per milogram of oil.

The foregoing figures represent, of course, the oil losses and does not imply that these amounts would suffice for initial lubrication, and run the distances stated.

On industrial machinery with open bearings, it is stated the average minimum amount of lubricants is 1 pound for each 36 million square inches of surface rubbed over or about 85 square inches per milogram of lubricant.

These areas of rubbing surfaces are calculated on the surface of the journals plus the surface area of the bearings.

Cylinder Oils

Examining average specifications for cylinder oils used for both low and high steam pressures, it is found that the following physical characteristics are demanded:

For low steam pressures (where high-grade oil is not required) the oil—

Must contain not less than 5 per cent acidless animal oil.
Must have a flash test of at least 450 deg. Fahr.
Must have a fire test of at least 500 deg. Fahr.
Must have a cold test of at least below 50 deg. Fahr.
Viscosity at 212 deg. must not be less than 100 sec.

For high steam pressures the oil—

Must contain not less than 5 per cent acidless animal oil.
Must have a flash test of at least 550 deg. Fahr.
Must have a fire test of at least 575 deg. Fahr.
Viscosity at 212 deg. must be less than 150 sec.

Cylinder and valve lubrication—especially on steam locomotives—present perhaps the greatest of lubricating difficulties, while high-pressure stationary power is comparatively free from difficulty, owing to the fact that high steam temperatures will readily atomize a good-grade oil and that there is a minimum amount of saturation in the cylinders. On low pressure there is a lack of the higher temperature necessary to atomize a good oil, and the condensate in the cylinders is excessive.

The difficulty of locomotive-cylinder lubrication is principally due to the fact that the exhaust pipe terminates in the smokebox and, when drifting, the vacuums in the cylinders—at the time the exhaust valve opens—cause a rush of coal gases into the cylinders which, as may be readily understood, is most destructive to lubrication. Again, the locomotive's continuous starting and stopping cause a variety of saturated conditions in the cylinders.

In an atmosphere of steam the heavy cylinder oil before mentioned will have about the following percentage of votalization:

Temperature, deg. Fahr.	400	500	600	700	800
Percentage of votalization	0.5	5	18.9	44	99

The remainder of the oil (if an excess amount has not been applied) will atomize in the steam and be carried to and gather on the surfaces of the cylinder and valves. It is possible to lubricate valves and cylinders using steam at 600 deg. Fahr., with a good lubricant of 525 deg. Fahr. flash point, and this may be done successfully with the right quality of valve oil, although it is sometimes difficult to convince those in charge of engines using high-pressure superheated steam that it can be, as they insist that the flash point should be higher than the maximum temperature of the steam. This idea was mostly prevalent at the time of the advent of super-heated steam locomotives, and cylinder oils were accordingly made of a very high flash test. But the results were so unsatisfactory due to the fact that such oil did not volatilize or atomize readily in the steam, that the mistake of this theory was evident.

Exhausive tests have shown that a high-grade cylinder oil with a flash test of 525 deg. Fahr. will not burn in a cylinder even at a steam temperature of 1000 deg. Fahr., if gases and atmosphere are excluded. The oil can be discerned under these conditions in the form of mist of fog, but if air or other gases are admitted at this period the oil will immediately burn. The critical temperature is apparently above 560 deg., which shows that locomotives must not be shut off entirely when the cylinder temperature is at a maximum.

Although this oil will not burn even at these high temperatures, still they often bring about a condition under which it is difficult to get lubrication on the walls when using the above mentioned oil, and this is not due to the lack of the lubrcating qualities of the oil, but due to the fact that atomization and volatilization is excessive, and the oil will not condense on the walls to give proper lubrication when the temperature of these parts reach a high dgree of heat due to the engine handling heavy tonnage and using long cut off for extensive periods. Under such conditions the use of a less volatile oil is very often necessary.

Another trouble encountered in cylinders and valves is in the form of deposits commonly but erroneously called carbon. But if a good grade of oil has been used and these deposits are analyzed, it will be found that there is but a small trace of carbon and the average analysis will show that on stationary engines the deposits consist principally of magnesium, sodium, etc., which have been carried over from the boilers, and which, when combined with the oil in the cylinder together with a little iron rust, form a deposit that is often blamed on the oil. A common form of deposit, when analyzed, is shown to consist of magnesium, sodium, or mud, 52 per cent; petroleum oil with an amount of saponifiable matter, 30 per cent; oxide of iron, 15 per cent; carbon, 3 per cent; or in the case of cylinders of locomotives using superheated steam, carbonaceous combustible, 59 per cent; thick baked oil, 13 per cent; oily, gummy matter, 3 per cent; red ash (iron oxide), 25 per cent; small amount of carbon.

A well-lubricated cylinder should, on the removal of the cylinder head, appear dark and smooth; a light rubbing with a piece of paper should produce a bright polished surface. If the cylinder walls appear bright on first inspection, it is a proof of inefficient lubrication and high frictional wear. If the cylinder deposits show a high percentage of red oxide of iron (this should not be confused with iron rust) it shows there is an excess of free fatty acid in the lubricant. If the cylinder shows lack of lubrication on the bottom, or in spots elsewhere, it is evident that the oil is lacking in a proper percentage of animal oil.

The presence of carbon and high percentages of carbonaceous combustible in the cylinders of locomotives may be construed as evidence of poor handling on the part of the engineman. If oil is found in the steam chambers of the valves and there is an apparent lack of lubrication on the walls, it shows that the lubricant is too heavy in body to be atomized at the prevailing steam temperature. If oil is found in valve chambers or there is an unusually heavy coating on the walls, an excessive quantity of oil is being applied.

The amount of oil required for cylinder lubrication is generally based on the diameter and stroke of the cylinders, and without due consideration of the volume of steam used per mile, while in many cases the latter is the factor that controls the amount of oil that should be applied.

A locomotive may be operating at high speed and using high superheat steam, and lubrication may be perfect with 6 drops of oil to each side due to the fact that, although there is a large area rubbed over, still the maximum and average cylinder wall temperature is low on account of short cut-off being used, whereas the same engine running at half the speed with a heavy tonnage and long cut-off will require an increased amount of oil on account of the high cylinder temperatures and perhaps excess volatilization of the lubricant.

In all cases of lubrication where the heat is produced from a foreign source (and not the generated heat of friction) such as cylinder lubrication, then the oil requirements bear a closer relation to the volume and temperature of that heat than it does to the amount of surface rubbed over.

One of the greatest troubles in lubrication is that the users want to lubricate everything out of one oil can, and in many cases the oil is stretched to the breaking point.

Lubrication of Cylindrical Bearings

In most of the printed instructions on the lubrication of cylindrical bearings will be found the following injunction: "Use an oil of just sufficient viscosity so that the film will bear the load at the required pressure per square inch and at the required journal velocity."

To my mind such instructions are much the same as advising the building of a machine to stand a load of 100 lbs., without providing any factor of safety to insure that it will not fail at a load of 101 lbs. A proper—even though a conservative—safety factor is just as necessary for lubricants as for any power mechanism, because the lubricants are subjected to just as many unusual loads and strains. This makes it necessary to pay some penalty in friction of the lubricant as a factor of safety just as one pays for excess weight in a machine for the same purpose; for if such provision is not made, constant failures will result.

Conditions can readily be pictured where the safety factor of the lubricant requires a comparatively small margin, such as in power plants where speeds are uniform, where the foundations of all bearings are rigid, where a circulating oil system is used, and also where—it goes without saying—supervision and repairs are efficient. But a very small percentage of lubricants is used under such conditions.

An absolutely ideal lubrication performance is not possible, or at least is not practicable, to obtain. This for the reason that it would require an almost endless number of different oils to lubricate even an ordinary machine, on account of the widely varying velocities, loads, and conditions under which the machine operates. If the general theory of lubrication is correct, as we are all inclined to agree, then any one kind of a lubricant has but a restricted range for efficient lubrication, and the lubricant which does not keep solid friction and wear at a minimum under all conditions does not fully meet the requirements of a lubricant in the fullest sense.

A condition met with in lubrication that does not seem to be fully apparent to the average user of oils, is that frequently there are chemical or physical imperfections in the metals of the bearings of journals, or some mechanical defects in the fitting of these parts that are not discernible by the naked eye. Yet tests will clearly indicate that excess friction and correspondingly high temperatures can be, and often are, caused by variations in the smoothness of the bearing or journal surfaces that cannot be easily detected, or in fact cannot be detected with the naked eye.

I have at various times carried out temperature and friction tests on several sets of bearings and journals made from the same materials and with the same mechanical construction and adjustment of the bearing fit as closely as it was possible to make them with micrometers, but when tested with the same lubricants, loads, velocities, and atmospheric temperatures they produced entirely different frictions and temperatures, and a thorough calibration and examination did not reveal any mechanical difference in the bearings. The inference should not be drawn from this that either of these bearings would give trouble by excess heating in service, but the example goes to prove that even infinitesimal defects may cause heating, and that in tests it is a difficult matter to determine fully or accurately the true friction of any lubricant.

As a practical illustration of this: At one of the largest and most important passenger terminals on a certain large railroad, where about 3000 pairs of wheels were changed per year, there was a general passenger-car foreman who was familiarly known as the "journal bug," due to the fact that he made a particular hobby of the surface finish of journals. After a journal was removed from the turning lathe with an apparently perfect finish, he would have it placed in a pair of improvised centers and run a lead lap lubricated with oil on it until another journal was turned; these journals were then thoroughly protected until placed in a car. What was the result? Although the majority of cars were of the heavy steel type and made the initial run of 142 miles without a stop during the year considered, only two journals out of the six thousand applied gave any serious trouble by heating on the initial run. This resulted from finishing a journal beyond what would ordinarily be called perfect. Now, if the oil film used in lubrication is of the thickness claimed by some authorities, why should finishing journals beyond an apparently good face thus improve their initial running temperatures?

Temperatures

The great majority of bearings (medium-speed journals) on industrial machinery operate at temperatures of from 100 to 130 deg. Fahr. with ordinary atmospheric temperatures. Such bearings are considered too hot when their temperature reaches 80 deg. above the temperature of the room where they are situated. This does not apply to the entire range of lubricated bearings as the temperatures of locomotive driving journals and engine-tender and car bearings often far exceed this margin.

At or near the surface of a locomotive bearing the average running temperature is about 240 deg. Fahr., on bearings of locomotive tenders and cars about 180 deg. I have tested car journals running at 275 deg. and driving journals at 300 deg. without either of them showing any bad results from such temperatures, but do not infer that the temperatures are not too high or that bad results would not take place were they continued, as I simply give the figures to show that in railroad lubrication the lubricant must have a very considerable factor of safety to meet the unusual conditions constantly encountered. Increased load per square inch due to heavy piston thrusts, slack bushes or bearings, excessively high or variable speeds, unequal load on bearings due to wedges sticking or faulty, damaged equalizing gear, dust and grit from ballast, heavy and high-speed hubbing of driving and engine-truck-wheel hubs, are some of the obstructive conditions peculiar to this service. While no lubricant can be expected to maintain normal running temperatures under these conditions, the very exigencies of the service demand that it be of a quality capable of holding these liabilities under reasonable control to obviate failures.

The average railroad official is not very much interested in either friction or running temperatures, but what he does demand is a lubricant that will meet successfully occasional or even frequent adverse conditions, eliminate failures on the line, and not cause excess wear of lubricated surfaces in general. Yet consideration of the first-mentioned factors is necessary in the intelligent selection of a lubricant that can deliver and maintain the efficient service thus expected.

The velocities of journals cover an extremely wide range, steam turbines having been built that have a velocity of 30,000 r.p.m. and in textile mills may of the spindles run at 11,000 r.p.m. However, these have a very light bearing load, and, as the velocity at which turbines operate creates a tendency for them to rotate about the gravity axis instead of the mechanical axis, special floating bearings are used in many cases. On railroad equipment the journal velocities range from about 800 to 1200 ft. per min. at a train speed of 60 miles per hour, but in general the loads carried on railroad journals are much greater than those on other classes of machinery.

Freight-car-journal loads run as high as 470 lb. per sq. in., while locomotive driving journals carry a dead load of from 200 to 250 lb. per sq. in., and the maximum thrust load on these is very high. Main crankpins have a thrust load as high as 2000 lb. per sq. in., and many of the journals are often subjected to much greater load for a protracted period due to defects in the equalizing gear, etc. This together with the variable speeds of trains, dirt and grit picked up, high temperature due to hub friction, moisture from rain and snow, and changing atmospheric temperatures, combine to make the lubrication of railroad equipment so liable to difficulties that the use of the very best oils procurable for the purpose—irrespective of what the unit cost of the lubricants may be—is not only advisable but absolutely essential to efficient and satisfactory operation.

Bearings may be classed generally under two divisions, journal bearings and thrust bearings. Journal bearings are cylindrical and the load is carried at right angles to the axis of the bearing. When the load is carried in a line parallel to the axis, we have what is called a "thrust" or "step" bearing. In addition, a further class might be added consisting of those bearings which permit moving parts to slide over them. These are known as "sliding-contact" bearings.

But from a lubrication standpoint it is necessary to differentiate further as there are a variety of conditions presented under each of the main classes. A few of these are:

Dead-running journals with uniform load always applied in one direction and a constant journal velocity of over 100 ft. per min.
Bearings where the load is constantly shifting from one side of the bearing to the other, such as the crankpins and main bearings of a reciprocating engine, and where the load is not uniform.
Bearings where the motion is reversible.
Bearings with journal velocities below 100 ft. per min.
Bearings subjected to heat other than that generated by bearing friction.
Bearings subjected to moisture.
Bearings exposed to low atmospheric temperatures.

There are many others, and in almost every case a different class of lubricant is required, and often a different method of application.

Methods of Applying Lubricants to Bearings

The difficulty presented in supplying proper lubrication to a cylindrical bearing arises from the fact that the lubricant will not flow at right angles to the axis of the journal, nor parallel to the line of surface motion, but has a tendency to flow at various angles from such lines, and always toward the ends.

Such flow action is readily understood when the available pressures on the film under the load area at various points on the bearing are taken into consideration. For example, if a row of holes are drilled one inch apart in a bearing parallel to the axis and a few degrees past the center of the load area and are connected to pressure gauges, it will be found that the pressure on the oil film is lowest at the outer ends and increases as the center is approached. The center gauge will register an amount of pressure per square inch about twice that of the bearing load per square inch. If the row of holes is drilled at right angles to the axis of the bearing (and in the center of bearing length) and connected to pressure gauges, the readings will show much the same as above, with the difference that the minimum pressures are lower and the pressure increases at a more rapid rate toward the center of the load area.

We therefore cannot expect that the lubricant will flow toward the point of highest pressure, and this is demonstrated by a simple illustration. Take a car journal—or any journal—say, 10 in. in length, and apply a piece of saturated packing 2 in. wide to the center of this journal when in motion. The result will be that a film of oil will spread all over the journal surface, which shows that the oil has a tendency to flow toward the ends and away from the area of highest pressure. Now remove the waste pad from the center position and place instead a packing 2 in. wide at each end of the journal, and it will be found that the center of the journal cannot be lubricated in this manner.

It must then be evident that on account of the angle followed by the flow it is a difficult though highly important matter to lubricate the center of a journal at the point where pressure is the greatest—and this is the particular place where adequate lubrication is most required. Some authorities recommend elaborate designs of grooves as a means of distributing oil to the ends of the bearing. As a matter of fact, there is no necessity of worrying about getting oil to the ends of the bearings, and if any groove is employed it should be one designed to prevent such a flow to the ends and assist in diverting it toward the center of the bearings. It is my opinion that in general all such grooving should be angular, with the vertex in the center of the bearing length.

It was formerly the practice on railroads (and in some instances continues to be) to have a groove cut in a bearing parallel to the journal axis and in the center of the load area. The result is that this groove simply breaks the lubricating film at the point where its stability is vital and allows the lubricant to flow to the outer ends of the groove and escape, where the pressures are less.

I have seen bearings designed which show the oil applied near either end, but none at the center of the bearing. In my opinion this is entirely wrong, for the reasons previously stated. Center application must be used for efficient lubrication. We have many times demonstrated by experience that any bearing, irrespective of its length, can be efficiently lubricated through central application, if proper quantities of the right lubricants are used. The best point for application is at the center of the length of the bearing and at right angles to the line of load, on the offside of the bearing.

Packing Waste

A great many classes of bearings such as locomotive and tender trucks, passenger and freight cars, mine cars, street cars, electric locomotives, etc., are lubricated by the application of oil-saturated waste. As these comprise a very important division of mechanical equipment, a few remarks on waste lubrication may be appropriate.

Considerable controversy has arisen from time to time as to what kind or class of waste is the most suitable for this purpose. The question is still an open one and those in charge of such equipment continue to use their own judgment in the matter, consequently nearly all kinds of waste are used.

Authorities state that a suitable waste for packing must contain not less than 50 per cent of ply-thread cotton to provide proper capillarity, and that 50 per cent must be a good grade of long-fiber wool to give resiliency and prevent excess glazing on the surface in contact with the bearing.

I doubt very much whether the capillarity efficiency of a waste is of any great benefit in this class of lubrication, and my reason is this:

The true relative capillarity as between different liquids is tested by tubes, which may be set in either a vertical position or on an angle with their bottom ends in the liquid, packing waste functions in the same manner, as the spaces between the minute fibers form tubes. But if capillary tubes were pliable and were twisted up and rammed into a bearing with perhaps both ends in the liquid or no ends in the liquid, they could hardly be expected to act in the manner it is stated and expected that packing waste will act.

In the care of railroad signal lanterns the company with which I am connected instructs the users to be very careful in applying the burners to avoid any twists in the wicks, as these twists will prevent the flow of oil in a capillary manner through the wick. Such is actually the case, and it is reasonable to suppose that the principle is as applicable to waste strands as it is to wicks.

A simple test will show that, in the lubrication of car journals with saturated waste, capillarity of waste does assist to some degree, but that it is not the sole agent of such lubrication. Pack a car-journal box with saturated waste and put in into service; after a stated number of miles, even though the packing may have been kept up to the journal by lifting it on the surface with the small hooks used for the purpose, the temperatures will gradually increase, although there is plenty of oil in the box. But this oil will be found at the bottom where it has gradually filtered down through the waste, and will not return to the journal by capillary attraction in sufficient quantities to maintain normal temperatures. Now what is necessary to do again to bring these temperatures back to normal? Simply this: a packing tool must be applied to spade up the packing and force the oil up through the waste, or, in other words, resaturate the waste.

On this account one of the essentials of an efficient lubricant for this class of service is that it shall possess the property of being able to remain in suspension in the waste for the maximum length of time at running temperatures, and the best waste is the kind that will hold the maximum amount of oil in suspension for the maximum time at running temperatures. This does not, of course, refer to any of the patented methods of waste lubrication where the waste is held in a frame in straight strands with one end in the oil ind the other in contact with the journal.

The following data regarding the capillarity of different wastes may be of interest:

Kind of Waste	*Height of left, in*	*Time consumed*	
		min.	*sec.*
Cotton slasher, tight-spun	2	30	
Cotton-ply thread	2	1	
Wool skein yarn	2	6	20
Axminster merino wool	2	0	29
Ingrain merino wool	2	0	30

On a resiliency test the decrease with wool was 23 per cent and with cotton 45 per cent; these were the resiliency averages when tested with pressures of 140, 70, 30 and 7 grams per square in. on an enclosed column of waste 3 in. high.

Hot Bearings

On heavy machinery, and particularly on railroad equipment, heated bearings are not only a common occurrence but are considered a costly and a dangerous menace to efficient and economical operation.

What is the cause of a bearing "running hot," as it is commonly termed? There is just one cause and that is the absence of the oil film between the bearing and the journal on the area of a bearing load. This oil film may have been eliminated through any one or more of various causes, such as lack of oil supply, application of the oil at a wrong point with relation to load point on the bearing, oil of too low viscosity at running temperatures to carry the bearing load, journal velocity either too low or too high in relation to oil viscosity, bearing fitted too tight to journal, load on the bearing unequally distributed, packing not in contact with journal, packing glazed on surface next to the journal due to lack of oil on such surface, new brasses applied without a sealed crown fit—allowing oil to by pass through openings in crown, oil filtering down to the bottom of the oil box where it cannot be brought up to the bearing by capillary attraction due to packing-waste condition and location. I have never yet seen a hot box in railroad service due to dearth of oil in the box, but certainly many due to lack of oil on the journal.

One of the most common expressions regarding hot boxes in railroad service is "That the bearing was heated due to the surface of the waste glazing over." This idea is misleading because the glazing is caused by lack of lubrication on the journal and on the surface of the waste, and therefore glazing and hot box may be classified together as they are both the result of want of efficient lubrication.

Now what takes place in a bearing and journal when they start to overheat and finally fail: First the oil film will gradually decrease in viscosity due to increasing temperatures until it has not sufficient body to carry the load, and also the temperature reduces the surface tension of the lubricating film causing it to recede from the point of highest heat (which is the center of length of the load area), and then mental friction takes place, and there is a corresponding rapid generation of heat that cannot be radiated by the surrounding mass. This condition is further aggravated at this point by another; the heat generated in the journal is radiated in both directions through the center of the journal, leaving the journal at the center of the bearing at a much higher temperature than at the ends. Consequently the journal becomes larger in diameter at the middle of the bearing on account of this expansion and a greatly increased load at that point results, and finally the metal in the car bearing breaks down when the temperatures reach about 420 degrees.

The majority of overheated bearings can be readily detected by the odor and appearance of the gases thrown off before they reach a very high temperature; however, there are cases especially in freight service at night where hot bearings are not so readily discerned, because in many cases the packing in the boxes is old and dirty, and journal may be heated to a degree that makes it easily broken by shock and yet not show any combustion that is observable, and under many atmospheric conditions the gases thrown off will float low and the odor from them may not be smelled by the trainmen in the caboose, but such odors can readily be discerned by going to the lowest step of the caboose and such should be done periodically in night service.

The methods of preventing heating of boxes in railroad service are too numerous to mention here but the larger percentage of them can be prevented by keeping sufficient oil at the surface of the waste pad by a periodical forcing of the oil up through the waste with the packing iron.

New Steel Passenger Equipment for Norfolk & Western Railway

The forty-three all steel passenger cars built for this road by the Bethlehem Shipbuilding Corporation are now in service. The forty-three cars are made up of four different types as follows: 18 passenger coaches, 6 combination passenger coaches and baggage cars, 15 baggage and express cars, and 4 combined baggage and mail cars.

The cars were scheduled through the shops in order as shown above. While these cars are not as long as some of the steel cars now in service on this road, the interior of the car is arranged to obtain the maximum seating capacity.

The trucks are of the latest design, the frame and pedestal being of one casting and having 36 inches diameter forged steel wheels with 5½ by 10 inch journals. The brakes are of the clasp type which provide braking on both sides of the wheel.

The floors are of concrete composite material and therefore thoroughly fireproof.

The seats in the coaches are the road standard double passenger type and are constructed so as to afford comfort. The upholstered seats are of green plush, while those in the smoking compartment have pantasote covering.

The heating, lighting and ventilation of these cars is the very latest in construction. The cars are heated with the vapor system which is so arranged that a uniform temperature can be maintained. The electric lights are of a design of ample and uniform lighting. The ventilating system is of a special design, consisting of individual ventilators built in each window sash. The ventilators are so arranged that they may be operated by the passengers to afford such ventilation as desired without affecting other passengers.

The cars are also equipped with five ceiling fans so constructed as to circulate the air without creating a draft.

The exterior finish of the car is the standard tuscan red of the Norfolk & Western.

Notes on Domestic Railroads

Locomotives

The Mobile & Ohio Railroad has ordered 5 six-wheel switching locomotives from the American Locomotive Company. These locomotives will have 20 by 28 in. cylinders and a total weight in working order of 165,000 pounds.

The Southern Pacific Company will build eight Mountain type locomotives in its Sacramento shops. These locomotives are to be used in fast passenger service.

The Atchison, Topeka & Santa Fe Railway has ordered 10 Santa Fe type oil-burning locomotives from the Baldwin Locomotive Works.

The New Orleans Great Northern Railroad is inquiring for 3 Mikado type locomotives and 3 Consolidation type locomotives.

The Oliver Iron Mining Company is inquiring for from 8 to 12 eight-wheel switching locomotives.

The Chicago, Rock Island & Pacific Railway has ordered 25 Mikado type and 10 Mountain type locomotives from the American Locomotive Company.

The Missouri Pacific Railroad reported as inquiring for 25 eight-wheel switching locomotives, 5 Mountain type locomotives and 6 Pacific type locomotives,

The New York, New Haven & Hartford Railroad has ordered 10, three-cylinder Mikado type locomotives from the American Locomotive Company.

The New York Central Railroad has ordered one switching type oil-electric battery locomotive of 125 tons from the Ingersoll Rand Company, American Locomotive Company and the Electric Storage Battery Company which companies cooperate in its manufacture.

The Sydney & Louisberg Railway has ordered 2 six-wheel switching locomotives from the American Locomotive Company. These locomotives will have 19 by 26 in. cylinders and a total weight in working order of 132,000 lb.

Freight Cars

The Atchison, Topeka & Santa Fe Railway has ordered 500 box cars and 500 refrigerator cars from the Pullman Car & Manufacturing Corporation; 500 refrigerator cars and 300 gondola cars from the American Car & Foundry Company; 500 box cars from General American Car Company and 500 box cars from the Standard Steel Car Company.

The Chicago, Burlington & Quincy Railroad is inquiring for 1,000 box cars of 40-tons capacity.

The Chicago, Rock Island & Pacific Railway has ordered 250 hopper ballast cars from the Pressed Steel Car Company.

The Baltimore & Ohio Railroad is inquiring for 100 underframes and superstructures for caboose cars.

The Mobile & Ohio Railroad has ordered 250 flat cars, 150 hopper cars and 200 gondola cars from the Chickasaw Shipbuilding Corporation,

The Northern Pacific Railway is planning to purchase 500 freight cars and rebuild 500 logging cars in their own shops.

The Northwestern Refrigerator Line Company, Chicago, Ill., has ordered 1,020 refrigerator cars from the American Car & Foundry Company.

The Burlington Refrigerator Express Company has ordered 100 cane cars of 15-tons capacity from the Gregg Car Company.

The Canadian National railways is inquiring for 1,000 automobile box cars and 100 ballast cars of 50-tons capacity.

The Missouri-Kansas-Texas Railroad will build 500 freight cars in its own shops at Denison, Texas.

The Missouri Pacific Railroad has ordered 100 ballast cars of 50-tons capacity from the American Car & Foundry Company.

John Morrell & Company, Chicago, Ill., has ordered 100 refrigerator cars from the American Car & Foundry Company.

The Louisville, Henderson & St. Louis Railway has ordered 15, 40-ton stock cars from the American Car & Foundry Company.

The High Point, Thomasville & Denton Railroad is inquiring for 15 all steel box cars of 50-tons capacity.

The Chicago & Northwestern Railway has ordered 250 ore cars from the Pullman Car & Manufacturing Company.

The Pacific Great Eastern Railway is inquiring for 10 steel stock cars of 40-tons capacity.

The Barber Asphalt Company has ordered 200 tank cars of 10-000-gal. capacity from the General American Tank Car Company.

The Wabash Railway is inquiring for 1,000 automobile box cars of 40-ton capacity.

The Tidewater Oil Company is inquiring for 200 tank cars of 8,000-gal capacity.

The Northern Pacific Railway is inquiring for 300 gondola cars.

The Carnegie Steel Company has ordered 8 ore hopper cars of 75-tons capacity from the American Car & Foundry Company.

The New York Central Railroad has ordered 10 automatic steel air dump cars from the Clark Car Company.

The Boston & Maine Railroad contemplates coming into the market for 500 hopper bottom coal cars.

The Delaware, Lackawanna & Western Railroad has ordered 25 Rodger ballast cars from the Rodger Ballast Car Company.

The Mobile & Ohio Railroad is inquiring for 250 steel underframe flat cars; 150, 50-ton steel frame hopper cars; 200 double drop bottom gondola cars and 15 all steel air dump cars.

The Lehigh Valley Railroad has ordered 500 hopper cars of 70-tons capacity from the Standard Steel Car Company, also 500 double sheathed box cars of 55-tons capacity and 200 automobile cars of 50-tons capacity from the American Car & Foundry Company.

The Western Union Company is inquiring for 20 steel underframes and trucks for box cars.

The Buffalo, Rochester & Pittsburgh Railway will make repairs at its own shops to 500 gondola car bodies of 70-tons capacity.

The Missouri Pacific Railroad has ordered 750 automobile cars, 100 gondola and 20 caboose cars from the Mt. Vernon Car & Manufacturing Company; 250 hopper cars from the Standard Steel Car Company, 750 automobile cars from the General American Car Company, 250 stock cars, 500 box cars and 500 automobile cars from the American Car & Foundry Company.

The Chicago, Milwakee & St. Paul Railway has ordered 500 automobile box cars from the Pullman Car & Manufacturing Company and 500 stock cars from the Bettendorf Company.

The Chicago, Rock Island & Pacific Railway has ordered 500 box cars and 500 coal cars from the Bettendorf Company; 500 box cars from the American Car & Foundry Company; 250 flat cars from the Ryan Car Company and 500 automobile cars from the Standard Steel Car Company.

Passenger Cars

The Mobile & Ohio Railroad is inquiring for 6 steel baggage express cars 60 ft. long, 4 steel passenger coaches 69 ft. long, 2 steel passenger coaches with partitions and one steel mail baggage car 60 ft. long.

The Canadian National Railways is inquiring for 2 combination mail and express cars and 6 baggage cars.

The Chicago, Rock Island & Pacific Railway has ordered 40 suburban cars from the Standard Steel Car Company and 18 baggage cars from the American Car & Foundry Company.

The Baltimore and Ohio Railroad has ordered one combination passenger and baggage gas-electric rail motor car from the J. G. Brill Company, Philadelphia, Pa.

The New York Central Railroad has ordered 27 dining cars from the Pullman Car & Manufacturing Corporation.

The Chicago, Rock Island & Pacific Railway has ordered 5 dining cars and 10 coaches from the Pullman Car & Manufacturing Corporation.

The Pennsylvania Railroad has ordered 16 steel motor passenger cars from the American Car & Foundry Company.

The Mobile & Ohio Railroad has ordered 2 dual power plant combination mail, baggage and passenger gas-electric rail motor cars from the Electro Motive Company.

The Columbus & Greenville Railway has ordered one combination passenger and baggage gasoline rail motor car and one all passenger trailer car from the J. G. Brill Company, Philadelpria, Pa.

The Denver & Rio Grande Western Railroad has ordered 4 steel dining cars from the American Car & Foundry Company.

The Central Vermont Railway has ordered one gas-electric equipment for converting a storage battery car to gas-electric from the J. G. Brill Company, Philadelphia, Pa.

The Chicago & Northwestern Railway is inquiring for 100 coaches and 20 combination passenger and baggage cars.

The Chicago, Burlington & Quincy Railroad has ordered 10 coaches and one combination baggage passenger and mail car from the Pullman Car & Manufacturing Corporation and 15 baggage cars and 4 combination passenger and baggage cars from the American Car & Foundry Company.

The Pennsylvania Railroad has ordered 20 multiple unit cars from the Standard Steel Car Company, 15 from the American Car & Foundry Company and 15 from the Pressed Steel Car Company.

The Chicago, Aurora & Elgin Railroad is inquiring for 15 rail motor cars.

The Baltimore & Ohio Railroad is inquiring for 50 coaches, 15 combination passenger and baggage cars, 5 baggage cars with 30 ft. mail compartment and 10 baggage cars with 15 ft. mail compartment also ordered 5 dining cars from the Pullman Car & Manufacturing Corporation.

The Chicago, Burlington and Quincy Railroad has ordered one combination passenger and baggage gas-electric rail motor car from the J. G. Brill Company, Philadelphia, Pa.

The Gulf, Mobile & Northern Railroad is inquiring for 2 coaches.

The Chicago, South Shore & South Bend Railroad is inquiring for 10 motor cars and 10 trailers.

Buildings & Structures

The Baltimore & Ohio Railroad plans the construction of a new freight yard and engine terminal at Cincinnatti, Ohio.

The Pennsylvania Railroad has awarded a contract covering the construction of a 500-ton reinforced concrete automatic electric coaling station at East Rochester, Ohio.

The Atchison, Topeka & Santa Fe Railroad closed bids for the construction of a one-story warehouse at Argentine, Kan.

The Louisiana & Northern Railroad has awarded a contract for the construction of a frame machine shop at Homer, La., to cost approximately $10,000.

The Ft. Worth & Denver City Railway is preparing plans covering the construction of repair shops at Childress, Texas, to cost approximately $100,000 with equipment.

The Atchison, Topeka & Santa Fe Railway has authorized the construction of a three-story combined recreation center, apprentice school and fire station at Topeka, Kan.

The Louisville & Nashville Railroad has placed an order with the Roberts & Schaefer Company for the installation of sand handling machinery at Paris, Ky.

The Chicago, Milwaukee & St. Paul Railway will construct a hot water washing plant to serve a 35-stall roundhouse in Chicago, Ill., to cost approximately $53,000.

The Cleveland, Cincinnati, Chicago & St. Louis Railway has awarded a contract to the Roberts & Schaefer Company covering installation of automatic electric coal hoisting equipment for an existing coaling station at Greensburg, Ind.

The Pennsylvania Railroad has awarded a contract for the construction of coal handling plant facilities at Sodus Point, N. Y.

The Union Pacific Railroad is receiving bids for the construction of shop buildings and an engine house at Ogden, Utah.

The Reading Company is planning new terminal and station facilities for Atlantic City, N. J., involving a new passenger station, new passenger and freight yards and the widening of streets in the vicinity, to cost approximately $4,000,000.

The Yazoo & Mississippi Valley Railroad has awarded a contract to the Railroad, Water & Coal Handling Company, Chicago, Ill., for the construction of a 300-ton coaling station at Lambert, Miss., at a cost of about $50,000.

The Kansas City, Mexico & Orient Railroad plans have been prepared for the construction of a roundhouse and machine shop at McCamey, Texas.

The Missouri Pacific Railroad contemplates the construction of a water treating plant at Little Rock, Ark., to cost approximately $16,000.

The Louisville & Nashville Railroad has placed a contract with the Roberts & Schaefer Company, for the installation of sand handling machinery at Paris, Ky.

The Ft. Worth & Denver City Railway are preparing plans for the construction of repair shops at Childress, Texas, to cost approximately $100,000 with equipment.

The Boston & Albany Railroad has placed a contract for the construction of an enginehouse and layout at Worcester, Mass.

The Chicago & Northwestern Railway will construct an ice house of 1,500 tons capacity at South Pekin, Ill.

The Reading Company has awarded a contract to the Roberts & Schaefer Company, covering the construction of a "N. & W." type electric cinder plant at Trenton, New Jersey.

The Union Pacific Railroad are receiving bids for the construction of shop buildings and an engine house at Ogden, Utah.

The Chicago, Milwaukee & St. Paul Railway has awarded a contract for the construction of a machine shop, at Mason City, Iowa, to cost approximately $10,000.

The Louisville & Nashville Railroad has awarded a general contract for the construction of reinforced concrete brick and steel roundhouse, machine shop and office building at Evansville, Ind. at a cost of approximately $200,000.

The Louisiana & North West Railroad has awarded a contract for the construction of new shop buildings at Homer, La. to cost approximately $10,000.

Supply Trade Notes

J. H. Ridge has been appointed manager of the Pittsburgh branch of the **Timken Roller Bearing Service & Sales Company**; **G. G. Weston** has been appointed manager of the Omaha branch, with headquarters at Omaha, Nebr.; **Paul Ackerman** has been appointed engineer of the service department, with headquarters at Canton, Ohio.

M. J. A. Bertin, managing director of the **Societé Anonyme des Huiles Galena**, Paris, France, has been elected president of the parent company, **Galena Signal Oil Company**, Franklin, Pa., with headquarters at New York, N. Y., succeeding **L. J. Drake**, resigned.

F. J. Foley has been elected vice-president in charge of sales department of the **American Locomotive Company**, with headquarters at New York City.

Thomas R. Allen has been appointed assistant works manager of the **American Brown Boveri Electric Corporation,** with headquarters at Camden, New Jersey.

Joseph Beaumont has resigned as vice-president and director of the **Regan Safety Devices Company,** to engage in other business.

H. M. Sloan, as vice-president of the **Buda Company,** Harvey, Ill., will have complete charge of all sales activities of the company; **J. S. Dempsey** has been appointed treasurer to assume the duties formerly handled by **Mr. Sloan.**

A. C. Schleifer has been appointed mechanical engineer of the **E. A. Lundy Company,** Pittsburgh, Pa.

E. McCormick, vice-president in charge of financial affairs of the **Railway Steel Spring Company,** has been appointed vice-president in charge of sales, succeeding **F. J. Foley,** who has been appointed vice-president in charge of sales of the **American Locomotive Company.**

William I. Howland, Jr., has been appointed assistant general manager in charge of the bar bureau of the **Illinois Steel Company,** succeeding **B. E. Hamilton,** deceased.

The Billings and Spencer Company, Hartford, Conn., have just issued a very elaborate hand book and catalogue combined, on their drop forged tools.

The Vapor Car Heating Company, Inc., Chicago, Ill., have changed the location of their Boston office, from 53 State street to the Little Building, 80 Boylston street.

The Roberts & Schaefer Company have been awarded a contract by the New York Central Lines for one of their multiple pit "N. & W." type electric cinder plants for installation at Corning, Ohio.

The Armco Culvert Manufacturers' Association, Middletown, Ohio, is the name recently adopted by the **Armco Culvert and Flume Manufacturers' Association.** The change of name effects no change in the association's policy, and it will continue as before its research in all matters relating to drainage and irrigation, and to educational publicity for making this research known to those whom it will benefit.

Oakite Products, Incorporated, is the new name adopted by the **Oakley, Chemical Co.,** 22 Thames St., New York City, manufacturers of the "Oakite" materials used for all cleaning purposes in railroad locomotive, car and repair shops.

The board of directors of the **General Electric Company,** at its meeting in New York City, elected **Theodore Beran** of New York, **H. L. Monroe** of Chicago and **J. A. Cranston** of San Francisco as commercial vice presidents, in charge of the commercial activities of the company in the New York, Central and Pacific Coast districts respectively. **E. W. Allen,** manager of engineering, was elected vice president in charge of engineering, with offices in Schenectady. On account of the temporary absence of Vice President **F. C. Pratt** because of illness, **G. E. Emmons,** former vice president, was elected as acting vice president to take charge of manufacturing activities.

Orrin H. Baker has been appointed assistant general manager of rail sales division for the **Illinois Steel Company,** with headquarters at Chicago, Ill., succeeding **P. W. O'Brien,** deceased.

Electric Service Supplies Company of Philadelphia, Pa., announces that the address of their Pittsburgh, Pa., office has been changed from the Oliver Building to the Bessemer Building.

Westinghouse Electric Products Company of Mansfield, Ohio, and the **George Cutter Company** of South Bend, Ind., have been discontinued and merged into the parent company, the Westinghouse Electric & Manufacturing Company. In the future they will be designated as the Mansfield Works and the Street Lighting Department, respectively of the Westinghouse Electric & Manufacturing Company, the latter including the South Bend Works, which is one of the largest in the country devoted to the manufacture of street lighting equipment. The Mansfield Works is devoted to the manufacture of domestic electric appliances, including electric ranges and ovens and safety switches.

The National Pneumatic Company, New York, N. Y., announce that they will change their address from 30 Church Street, to the new Graybar Building, just east of the Grand Central Terminal, when this building is completed April 1.

The Molybdenum Corporation of America, Pittsburgh, Penn., announces that **G. M. Eaton,** Chief Mechanical Engineer of the **Westinghouse Electric & Manufacturing Company,** has become identified with their company in a sales engineering capacity.

At a recent meeting of the board of directors of the **American Car and Foundry Company, Dallas B. Pratt** and **F. F. Fitzpatrick** were elected directors of the company, and were also elected directors of the **American Car and Foundry Securities Corporation.**

Lester B. Paterson has resigned his position with the **American Locomotive Company** and is now connected with the **Combustion Engineering Corporation** as assistant production manager, with offices at 200 Madison Ave., New York City.

W. J. Savage, railroad service engineer of the **Anchor Packing Company,** has been promoted to assistant district manager with headquarters at Chicago, Ill.

Fred S. Doran has been appointed manager of the Cleveland plant of **Joseph T. Ryerson & Son, Inc.**

Philip Robinson, manager of sales of the **Gray Screw & Bolt Company,** Chicago, Ill., has been elected vice-president and general manager of sales.

The Gold Car Heating & Lighting Company has been recently awarded a decision in the patent litigation instituted by the Vapor Car Heating Company, Inc. On an appeal to the U. S. Circuit Court of Appeals for the Second Circuit this Court, in an Opinion by Judge Hough, has affirmed the decision of the trial court, which was mainly in favor of the Gold Company. This decision ends a long period of patent litigation between these two companies, and is the third important case in recent years in which the Gold Company has been victorious.

The effect of this decision is that the Gold Company's apparatus as manufactured for several years past, are held not to infringe the patents of the Vapor Company on which the suit was brought.

Items of Personal Interest

W. R. McMunn has been appointed superintendent of rolling stock of the Merchants Despatch, Inc., Rochester, N. Y.

J. Humphrey Hustis, Jr., has been appointed assistant to vice-president of the New York Central Railroad with headquarters at New York, N. Y.

C. E. Denney has been elected senior vice-president of the New York, Chicago & St. Louis Railroad, and the Lake Erie and Western Railway with headquarters at Cleveland, Ohio.

Walter L. Ross has been elected president of the New York, Chicago & St. Louis and the Lake Erie & Western Railway.

B. H. Mann has been appointed consulting signal engineer of the Missouri Pacific Railroad with headquarters at St. Louis, Mo.

W. B. Whitsitt, assistant mechanical engineer of the Baltimore & Ohio Railroad, has been promoted to mechanical engineer of the road with headquarters at Baltimore, Md.

C. P. Essman, assistant engineer of the Hocking Valley Railway, has been promoted to resident engineer of the new Chesapeake & Hocking Valley Railroad with headquarters at Asheville, Ohio.

A. G. Sandman, mechanical engineer of the Baltimore & Ohio Railroad, has been promoted to assistant to the chief of motive power with headquarters at Baltimore, Md.

Samuel Porcher, general purchasing agent of the Pennsylvania Railroad, with headquarters at Philadelphia, Pa., has been promoted to assistant vice-president in charge of purchases, stores and insurance. **Montgomery Smith,** purchasing agent, has been promoted to assistant general purchasing agent with headquarters at Philadelphia, Pa. **C. E. Walsh,** assistant purchasing agent, has been promoted to purchasing agent with headquarters at Philadelphia, Pa.

M. R. Garrison has been appointed assistant general freight agent of the New York Central Railroad with headquarters at New York, N. Y.

C. A. Whipple, assistant engineer on the Hocking Valley Railway, with headquarters at Columbus, Ohio, has been promoted district engineer in charge of construction on the new Chesapeake & Hocking Valley Railroad.

Robert Trimble, assistant chief engineer of the Pennsylvania Railroad, with headquarters at Pittsburgh, Pa., was appointed chief engineer of the Pennsylvania Railroad Company and the Pittsburgh, Cincinnati, Chicago & St. Louis Railroad.

P. M. Gault, assistant signal engineer of the Illinois Central Railroad, with headquarters at Chicago, Ill., has been appointed signal engineer of the Missouri Pacific Railroad with headquarters at St. Louis, Mo.

Timothy W. Evans, assistant vice-president of the New York Central Railroad, with headquarters at New York, N. Y., has been elected vice-president of the Indiana Harbor Belt and the Chicago River & Indiana Railroad with headquarters at Chicago, Ill.

C. R. Smith has been appointed assistant secretary of the National Railways of Mexico with headquarters at New York, N. Y., succeeding **Bartolome Carbajal,** resigned.

J. W. Mode, acting superintendent of the Amarillo division of the Ft. Worth & Denver City Railway, has been promoted to superintendent, with headquarters at Amarillo, Texas, succeeding **R. G. Fitzpatrick,** retired. The jurisdiction of **A. R. Ayers,** assistant general manager of the Nickel Plate district and the Lake Erie & Western district of the New York, Chicago & St. Louis, with headquarters at Cleveland, Ohio, has been extended to cover the system.

P. L. Peffer, general yardmaster of the New York, Chicago & St. Louis Railroad, with headquarters at Conneaut, Pa., has been promoted to terminal master at Buffalo, N. Y., succeeding **M. J. Nolan,** deceased.

Charles L. Simpson, assistant superintendent of the Minnesota division of the Minneapolis, St. Paul & Sault Ste. Marie Railway, with headquarters at Harvey, N. Dak., has been promoted to superintendent of the Missouri River division, with headquarters at Bismarck, N. Dak., succeeding **Scott W. Derrick,** retired.

Edward E. Stetson, principal assistant engineer of the Chicago Union Station Company, has been appointed assistant to the chief engineer of the Pennsylvania Railroad with headquarters at Chicago, Ill.

K. A. Lentz, erecting shop foreman of the Southern Railway, with headquarters at Spencer, N. C., has been promoted to shop superintendent with the same headquarters.

A. G. Mott, chief transportation engineer of the Railroad Commission of California, has been appointed chief engineer, succeeding **Lester S. Ready,** who has resigned.

The jurisdiction of **W. G. Black,** superintendent of motive power of the Nickel Plate district and the Lake Erie & Western district of the New York, Chicago & St. Louis Railroad, with headquarters at Cleveland, Ohio, has been extended to cover the system.

George W. Kittredge, chief engineer of the New York Central Railroad, with headquarters at Buffalo, N. Y., since 1906, has been retired under the pension regulations of that company. **F. B. Freeman,** chief engineer of the Boston & Albany Railroad, has been appointed chief engineer at Buffalo and east, succeeding George W. Kittredge, retired.

J. B. Graham, general foreman of the locomotive department of the Missouri Pacific Railroad, with headquarters at St. Louis, Mo., has been appointed master mechanic of the Wichita division, with headquarters at Wichita, Kan., succeeding **J. P. Downs,** resigned.

Samuel T. Wagner, chief engineer of the Reading Company, with headquarters at Philadelphia, Pa., has retired from active duty, and has been appointed consulting engineer. **Clark Dillenbeck,** assistant chief engineer, with the same headquarters, succeeding S. T. Wagner.

T. Devaney, master mechanic on the Clover Leaf district of the New York, Chicago & St. Louis Railroad, with headquarters at Frankfort, Ind., has been appointed superintendent of shops, with the same headquarters.

A. A. Smith, assistant superintendent of the Manitoba district of the Canadian Pacific Railways, with headquarters at Ignace, Ont., has been promoted to superintendent of the Lethbridge division, with headquarters at Lethbridge, Alta., succeeding **J. L. Jamieson,** transferred.

Lucius Seam has been appointed master mechanic in charge of the locomotive department, car shops and coal dock of the Copper Range, with headquarters at Houghton, Mich., succeeding **Gilbert Bisson,** resigned.

Obituary

Charles N. Whitehead, president of the Missouri-Kansas-Texas lines died on December 10 at St. Luke's Hospital, St. Louis, Mo., after an illness of nearly six weeks. Mr. Whitehead was born on January 23rd, 1878, at Princeton, Ill. His first position was that of messenger in the freight office of the St. Louis & Southwestern at Cairo, Ill., in 1892. In that same year he obtained a similar position in a freight office of the Missouri-Kansas-Texas. After promotions to stenographer, clerk and chief clerk, he was transferred to the superintendent's office at Smithville, Texas, in 1895, and later to Denison, and later he was again transferred to the general freight office at Dallas, Tex. In 1900 he served for a time in the office of the general attorney and the following year he returned to a superintendent's office. After three years spent in the general counsel office he was appointed assistant secretary of the railroad, with headquarters at New York City, and in 1906 he was elected secretary. In 1909 he was elected to the position of treasurer as well as that of secretary and this promotion was followed in 1913 by being promoted to assistant to the president. Mr. Whitehead was elected vice-president in charge of operation in 1914, becoming assistant to the receiver in 1915. With the advent of government control of the railroads he was made manager of the road. He was appointed chief operating officer for the receiver in 1920 and was elected executive vice-president on April 1, 1923, holding that position until he was elected president.

W. R. Scott, President of the Southern Pacific lines in Texas and Louisiana, died at Los Angeles, Cal., December 20, of a heart attack while visiting the office of the company.

Mr. Scott was born November 8, 1860, and started in the railroad business when he was twenty-one years old as a fireman on the Santa Fe. From 1884 to 1891, he was locomotive engineer and from 1891 to 1898, traveling engineer.

He became trainmaster, division superintendent and general superintendent on other Western railroads and joined the Southern Pacific in 1903 as assistant division superintendent. He became assistant general manager in 1907 and five years later, general manager.

During the war he was federal manager of the Southern Pacific, Western Pacific, Deep Creek and Tidewater Southern railroads. He had been president of the Southern Pacific's Texas and Louisiana lines since March 1, 1920.

John S. Mocre, general passenger and freight agent of the Chicago, South Bend & Northern Indiana Railway and Southern Michigan Railway died at South Bend, Ind., December 8 of heart failure. Mr. Moore had been connected with the companies since 1918. Previous to this he had been in the freight department of the South Shore Railway, and had been employed by the Wabash Railroad in the capacity of station agent at different points on their line.

Charles S. Lee, retired passenger traffic manager of the Lehigh Valley Railroad, died on December 21, in New York. Mr. Lee was born at Washington, D. C., and entered railway service with the Cleveland, Cincinnati, Chicago & St. Louis Railway. He was appointed chief clerk for the passenger department of the Denver & Rio Grande Western Railroad, and left that line in 1887 to become general passenger agent of the Colorado Midland, which line was built as a competing route to the Denver & Rio Grande Western Railroad. During his service with this road he was in charge of both the freight and passenger departments. In September, 1893, when the Colorado Midland became part of Atchison, Topeka & Santa Fe Railway he became general passenger agent of the Lehigh Valley Railroad with which company he remained until his retirement in 1915.

Frederick E. Sanborn, assistant to the president of the St. Johnsbury & Lake Champlain Railroad, and the Montpelier & Wells River Railroad (Boston & Maine Railroad) died on December 22, at St. Johnsbury, Vt. Mr. Sanborn was born in November, 1865, at Portsmouth, N. H., and was educated in the public schools of Portland, Maine. He entered the service of the Maine Central Railroad as a freight clerk in Portland in 1882. The following year he became passenger brakeman, advancing to baggage master in 1886, and to passenger conductor in 1892. In 1901 he became trainmaster on the Portland division and in 1903, assistant superintendent. He was advanced to superintendent of the Portland division in 1905, and to general superintendent in 1917. In 1918, he resigned and was assigned to the duties of claims investigator, retiring on pension on April 30, 1923.

New Publications

Books, Bulletins, Catalogues, Etc.

Machinists' and Draftsmen's Handbook, by Peder Lobben, M. E. Published by D. Van Nostrand Company, New York, N. Y. 487 Pages, 4½ x 7½. Flexible Binding. Price $3.00.

This book contains information relating to figures and problems in mechanics. Its the result of years of practical shop work and assumes that the draftsman and the mechanic are more interested in short cuts to correct results than in abstruse scientific development of theories of calculation. The book explains in the simplest way every proposition.

There are examples covering every phase of mechanics or mathematics worked out. The information is clear, concise, definite and understandable. Every one of the pages is full of practical data. There are tables giving useful information and quick answers. The book is well illustrated and makes for clearer understanding of the text.

Elementary Steam Engineering, by E. V. Lallier, Professional Engineer, University of the State of New York; Published by D. Van Nostrand Company, New York, N. Y. 298 Pages, 5¼ x 8. Bound in Full Buckram. Price $2.50.

This book is designed to give the engineering and operating man a basic discussion of the fundamental principles of steam engineering.

It tells in simple form not only the operation and theory of steam engines but also treats briefly their care, operation, and lubrication, and includes a brief chapter on internal combustion engines which explains without recourse to detail the principal features of the two-cycle engine, the four-cycle engine, the Diesel engine, and a few important details about timing, ignition and firing.

While primarily a textbook, designed for elementary courses in this subject, the book is so simply organized, so entertainingly written, and so easy to understand that it will be welcomed by those who wish to make a comparatively brief survey of the field of steam engineering.

The other chapters: Heat, Work done by steam during formation, Fuel, Boiler calculation, Care and operation of the steam boilers, Slide valve Engines, Rotary Engines, Packing and Insulation, Lubrication and Internal Combustion Engines.

Engineers will find this book a help to them in their work.

Railroad Calendar. The second annual calendar—showing where freight rates and passenger fares go—published by the Committee on Public Relations of the Eastern Railroads. The artist is Charles S. Chapman, member of the National Academy, who designed last year's calendar. The original, printed in ten colors, is of a large poster size—27½ x 42⅛ inches. It will be displayed in stations and elsewhere generally by the Eastern railroads in the near future. Individual copies are being supplied to the press this week.

The calendar is based on data furnished by the Bureau of Railway Economics. The distribution showing where freight rates and passenger fares go was arrived at in the same manner as last year. The Bureau took the total gross operating revenues of the Class I railroads for the latest year available (1925), and divided them by the 365 days in the year. It then computed in terms of average daily gross receipts the number of days taken by each item of expenditure.

A comparison of the 1927 calendar with that for 1926 shows the following:

For:	1927 Calendar	1926 Calendar
Wages	153 days	157 days
Locomotive fuel	24 "	27 "
Materials and supplies	69 "	70 "
All other operating expenses	25 "	24 "
Taxes	21 "	21 "
Interest and rents ("fixed charges")	41 "	41 "
Dividends	20 "	19 "
Surplus—available for improvements or reserves	12 "	6 "

In other words, operating expenses decreased by the receipts of seven days, and these seven days represent the increase in the earning power of the railroads 1925 over 1924. One of these seven days was given to railroad stockholders in dividends, and the remaining six days were passed to surplus. The earnings thus credited to surplus were—in large measure—used to pay for capital improvements during the year just closed.

The Committee on Public Relations of the Eastern Railroads will be glad to furnish additional copies of the calendar to interested members of the general public.

Railroad Lighting Equipment. The Pyle National Company, Chicago, Ill., has recently issued its catalog No. 101 which contains 46 pages and is illustrated with photographs of the products manufactured by the company. The catalog describes electrical accessories for locomotive shops, round houses and railway yards. Various types of headlight cases, reflectors, lenses, focusing devices, etc., are shown as well as different types of turbo generators. A large number of fittings for use in wiring locomotive cabs are also described and illustrated. Copies of the catalog may be obtained from the company headquarters at Chicago, Ill.

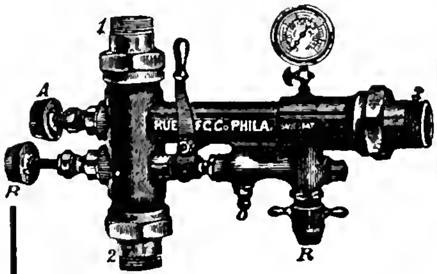
Flexible Metallic Connections. The Vapor Car Heating Company, Inc., Chicago, Ill., has just issued a booklet describing Vapor flexible metallic connections for use in train service and at terminals. The booklet shows the economical metallic steam connections on locomotives and passenger cars and in passenger yards. This booklet also gives the various sizes of Vapor flexible joints for use in passenger yards, enginehouses, stations, etc. Copies of the catalog may be obtained from the company headquarters at Chicago, Ill.

Build Out Fire With Concrete. (It Can't Burn) is the title of a folder recently distributed by the Portland Cement Association. It is profusely illustrated with buildings throughout the country that have been made fire resisting by being constructed of concrete.

Safety Rules for the Operation of Electrical Equipment and Lines. The Department of Commerce, Washington, D. C., recently published a booklet entitled: "Safety Rules for the Operation of Electrical Equipment and Lines." It may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 15 cents a copy.

Motor Maintenance Equipment. The Martindale Electric Company's new catalog No. 7 on Motor Maintenance Equipment is now ready for distribution. Included in it is commutator slotting and grinding equipment attractively illustrated and described as well as various maintenance specialties. One page in the catalog is devoted to the service rendered by the "Rental Department." Many companies do not have enough commutator grinding, undercutting or other repair work to warrant the purchase of equipment. To meet such conditions the Martindale Electric Company is prepared to loan equipment promptly at a nominal price.

Nitralloy.. The Ludlum Steel Company, of Watervliet, New York, has issued a bulletin on nitralloy. This is a special steel capable of being case hardened at low temperature without deformation. The Ludlum Company has obtained permission to use the patents controlled by Aubert and Duval Fres, Paris, France, which are based on discoveries of Dr. Fry of the Krupp laboratories. Copies of bulletin may be obtained from the company.



Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

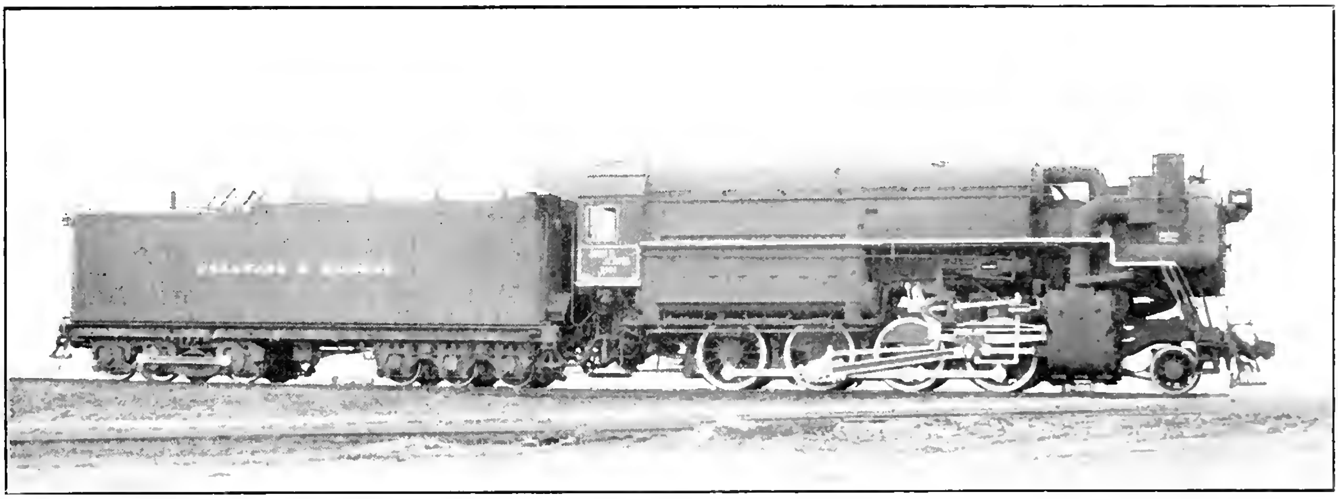
Vol. XL 136 Liberty Street, New York, February, 1927 No. 2

The Locomotive "John B. Jervis"

An Improved High Pressure Steam Locomotive Is Put in Service On the Delaware & Hudson

In the January, 1925, issue of RAILWAY AND LOCOMOTIVE ENGINEERING there was published in some detail a description of the locomotive "Horatio Allen," which at the time had gone into service on the Delaware & Hudson, and which had been built by the American Locomotive Company to the designs of Mr. John E. Muhlfeld.

The engine attracted considerable attention for there had been embodied in it more novelties of locomotive design and construction than had ever been incorporated in any single new locomotive that had ever been built in this country. Outstanding features were: the employment of 350 lb. steam pressure, the cross-compound principle and the water-tube boiler.



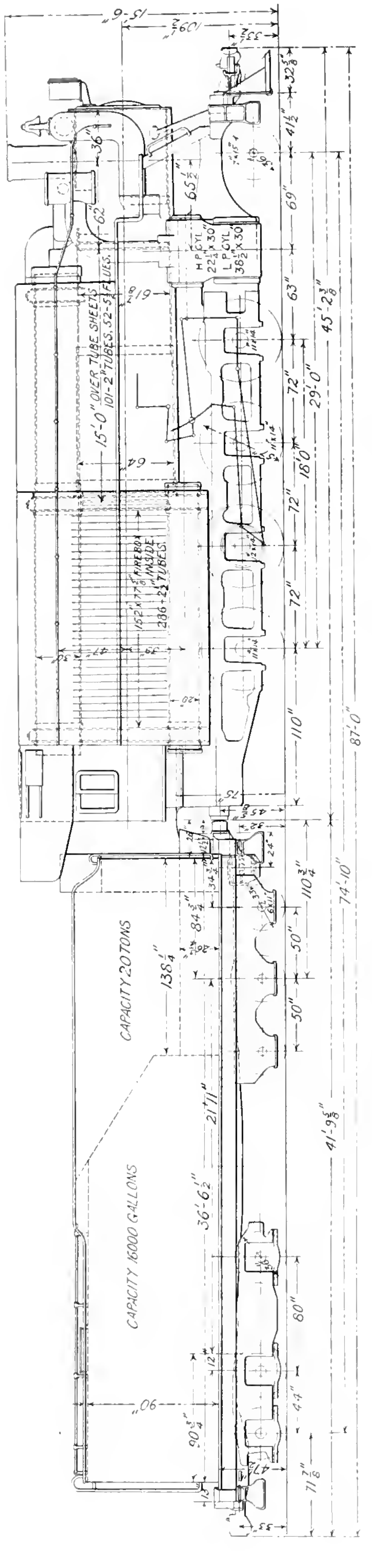
The Locomotive "John B. Jervis" in Service on the Delaware & Hudson—Designed by John E. Muhlfeld and Built by the American Locomotive Company

The "Horatio Allen" has been in regular road service between Oneonta and Mechanicville, New York, during the past two years, for experimental and development purposes. Advantages claimed for it in its performance record are: "Its reserve power; starting, acceleration and hauling power; adhesion to the rail; uniform speed on ruling pulls; ease of pumping boiler; maintenance of constant water level in the boiler; dryness of saturated steam as delivered to the superheater; less noise from exhaust steam and low fuel consumption."

It is reported that the "Horatio Allen" has made about 75,000 miles as a single crewed and a pooled engine, and that nothing has developed in its road service or terminal handling that necessitates it being given other than the same attention received by other steam locomotives. The reason for it not having made more mileage was due to the fact that repeated minor changes were necessary in connection with the experimental and test work to which the locomotive was being subjected, which related to high pressure and power, steam distribution, multiple expansion and like factors. The water tube boiler and the 350 lb. steam pressure is said to have given no trouble at all and that the remarkable efficiency and operating economy of the locomotive has been such that the construction of another and more simplified design has been developed by Mr. Muhlfeld and named the "John B. Jervis," that great pioneer railroad engineer of a hundred years ago, who did so much in the introduction of steam transportation in America.

The "John B. Jervis" was turned out of the Schenectady plant of the American Locomotive on January 28th and a few days later was turned over to the Delaware & Hudson Company and immediately put into road service between Oneonta and Mechanicville, New York.

As previously stated, the "John B. Jervis" is an improved "Horatio Allen." Based on experience with the latter, the steam pressure has been raised to 400 lb. per sq.

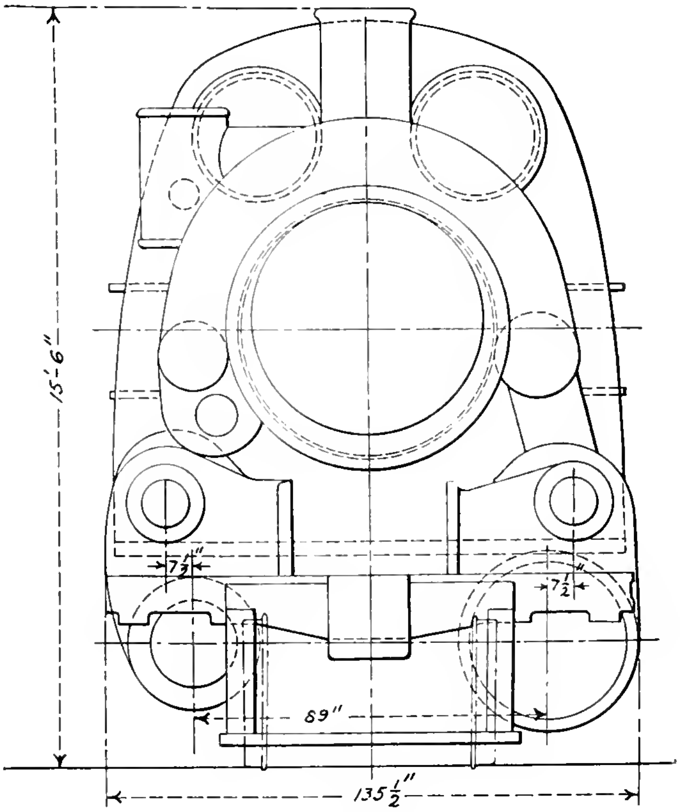


Side Elevation of the New High-Pressure Locomotive "John B. Jervis" on the Delaware & Hudson

in., some of the surplus weight has been eliminated, the boiler and machinery design has been improved, and the jacketing of the cylindrical and firebox portions of the boiler have been remodeled.

Particular attention has been given to improving firebox draft and combustion, in combination with reduction in cylinder back pressure. A trial application of the German State Railways type of smokebox draft appliances has been installed. This, in combination with increased gas area through the fire flues and tubes, it is hoped, will provide an adjustment which will substantially reduce the cylinder back pressure as well as improve combustion and fuel efficiency. The initial road performance of the "John B. Jervis" indicates that considerable will be accomplished in this direction.

For the purpose of eliminating heavy, long freight train stops, the fuel and water capacity of the tender has also been increased, and the tender has been equipped with six-wheel trucks, the rear truck being a six-wheel type of Bethlehem auxiliary locomotive.



Cross Section of Locomotive "John B. Jervis"

In the "John B. Jervis" locomotive special attention was given to the cab and boiler head arrangement, fittings and mountings, both general and detailed. This has been worked out very satisfactorily. The engineer has a very comfortable seat, and every device that he is required to operate is conveniently located within easy reach. On the fireman's side there is ample space for the fireman and the head brakeman to be seated. Furthermore, the cab is exceptionally well ventilated and the design provides clear vision windows on each right and left sides at the front of the cab, which are very satisfactory.

Mr. Muhlfeld and others interested in the introduction of the design feel that the "John B. Jervis" is a substantial step in advance, with respect to efficiency and economy in boiler and engine design and operation.

As soon as the locomotive has been broken in and dynamometer tests have been made, its performance record will be made the subject of further notice in the pages of RAILWAY AND LOCOMOTIVE ENGINEERING.

Weights of the Locomotive "John B. Jervis"

The following weight was taken with a fire on the grates, ashes in ashpan, sand, two men in the cab, two gauges of water in the boiler and other conditions approximating the road working condition of the locomotive.

Engine

Engine Truck	41,500 lbs.
Front Drivers	73,600 "
Intermediate Drivers	73,700 "
Main Drivers	73,900 "
Rear Drivers	73,800 "
Total Weight on Drivers	295,000 "
Average weight per pair of Driving Wheels	73,500 "
Total Engine Weight	336,500 "

Tender

Front Truck—Light Weight	53,770 "
Loaded "	143,350 "
Rear Truck—Light Weight	75,150 "
Loaded "	159,650 "
Total Tender Weight—Light	128,920 "
" " " —Loaded	303,000 "

Additional information in regard to the changes made in the "John B. Jervis" as compared with the "Horatio Allen" is given in the following table:

Comparative Locomotive Data

ITEM	"HORATIO ALLEN"	"JOHN B. JERVIS"
Type	280 CS 348	280 CS
Spec. or Shop No.	Shop No. 62765—Spec. A-10973	Shop No. 67059—Spec. A.-10973-A
Road	Delaware and Hudson	Delaware and Hudson
Track Gauge	4 ft. 8½ in.	4 ft. 8½ in.
Fuel	Mixed Anthracite and Bituminous	Mixed Anthracite and Bituminous
Cylinders	23½ in. and 41 in. x 30 in.	22¼ in. and 38 in. x 30 in.
Drivers	57 in.	57 in.
Boiler Pressure	350 lbs.	400 lbs.
Tractive Power, Simple	84,300 lbs.	84,300 lbs.
Tractive Power, Compound	70,300 lbs.	70,300 lbs.
Tractive Power, Booster	18,000 lbs.	18,000 lbs.
Factor of Adhesion, Simple	3.54	3.54
Factor of Adhesion, Compound	4.24	4.24
Weight on Pony Truck	49,500 lbs.	41,500 lbs. (Est.)
Weight on Drivers	298,500 lbs.	295,000 lbs. (Est.)
Weight on Trailer Truck	— —	— —
Weight, Total—loaded	348,000 lbs.	336,500 lbs.
Weight, Total—light	319,200 lbs.	310.800
Wheel Base Rigid	18 ft. 0 in.	18 ft. 0 in.
Wheel Base Driving	18 ft. 0 in.	18 ft. 0 in.
Wheel Base Engine	29 ft. 0 in.	29 ft. 0 in.
Wheel Base Tender	23 ft. 8 in.	30 ft. 9 in.
Wheel Base Engine and Tender	65 ft. 7¾ in.	74 ft. 11½ in.
Boiler, Type	Water Tube—Fire Flue	Water Tube—Fire Flue
Boiler, Diameter	61⅞ ft. I. D. 66⅛ ft. O. D.	61⅞ in. I. D. 66 3/16 in. O. D.
Boiler, Firebox Size	137 in. x 75 in.	152 in. x 77⅝ in.
Grate	137 in. x 75 in.	152 in. x 77⅝ in.
Combustion Chamber	None	None
Grate Area	71.4 sq. ft.	82 sq. ft.
Superheater, Type	Spiral Single-Loop	Spiral Single-Loop
No. of Flues and Diameter	42—5⅜ in.	52—5½ in.
No. of Tubes and Diameter	145—2 in.	101—2 in.
Water Tubes, Vertical, No. and Diameter	204—2 in. 102—2½ in	286—2½ in.
Water Tubes, Horizontal, No. and Diameter	8—3 in.	8—3 in.
Fire Flue Spacing	¾ in.	¾ in.
Fire Tube Spacing	¾ in.	¾ in.
Fire Tube Length	15 ft. 0 in.	15 ft. 0 in.
Fire Flue and Tube Length	15 ft. 0 in.	15 ft. 0 in.
Water Tube Vertical Spacing	5 in. x 2⅞ in.	5 ft. x 3 in.
Water Tube Vertical Length	Average 69⅝ in.	Average 67⅞ in.
Water Tube Horizontal Spacing	4 3/16 in. x 4 3/16 in.	4 3/16 in. x 4 3/16 in.
Water Tube Horizontal Length	11 ft. 6 in.	12 ft. 9 in.
Water Tube Horizontal Inclination	1 in. in 15.26 in.	1 in. in 17.05 in.
Heating Surface—Fire Flues	881	1116
Heating Surface—Fire Tubes	1132	788
Heating Surface—Arch Tubes	63	67
Heating Surface—Firebox Sheets	213	287
Heating Surface—Vertical Water Tubes	832	788
Heating Surface—Horizontal Water Tubes	79	70
Heating Surface—Total Firebox	1124	1150
Heating Surface—Total Boiler	320	3200
Superheater Heating Surface	579	700
Center of Boiler to Rail	9 ft. 1½ in.	9 ft. 1½ in.
Compound System—Type	Mellin	Mellin
Valves Type and Diameter	Piston—H. P. 12 in. L. P. 14 in.	Piston—H. P. 12 in. L. P. 14 in.
Valve Gear Type	Young	Walschaerts
Frames Width	5½ in.	5½ in.
Driving Journals, Diameter and Length Main	12 in. x 14 in.	12 in. x 14 in.
Driving Journals, Diameter and Length—Other	11 in. x 14 in.	11 in. x 14 in.
Engine Truck Wheel	36 in.	36 in.
Trailer Truck Wheel	None	None
Stoker	None	None
Trailer Truck	None	None
Booster	M and L. B 1	M. and L. B 1
Feed Water Heater	None	None
Tender, Water Capacity	9,000 Gals.	16,000 Gals.
Tender, Fuel Capacity	15½ Tons	20 Tons
Tender, Weight Loaded	197,800 lbs.	312,000 lbs.
Tender, Type of Water Tank	Acme Water Bottom	Ralo Acme
Tender Wheels, Kind and Diameter	Davis Cast Steel—33 in.	Davis Cast Steel—33 in.
Tender Axles, Size of Journals	6 in. x 11 in.	6 in. x 11 in.

Calculated Locomotive Data

Boiler Horsepower	3560	3440
Boiler H. P. per sq. ft. Tube Area	510	450
Cylinder Horsepower	3000	3020
Ratio, Boiler Horsepower to Cylinder Horsepower	118.8	114
Weight of Engine in Working Order per Cylinder H. P.	116	112
Weight of Engine in Working Order per Boiler H. P.	98	99
Ash Pan Air Opening—Square Inches	1107.5	1645.5
Grate Air Opening—Square Inches	3713	4600
Per cent. of Air Opening through Grate Area	36.1%	33.9%
Superheater Flue Gas Area—Sq. In.	663	862
Fire Tube Gas Area—Sq. In.	342	230
Total Flue and Tube Gas Area—Sq. In.	1005	1092
Per cent. of Total Gas Area through Superheater Flues	63%	78.8%

New Equipment Installed in 1926

Class I railroads in 1926 placed in service 2,399 locomotives, according to reports filed by the carriers with the Car Service Division of the American Railway Association.

This was an increase of 666 locomotives over the number installed in 1925, while it also was an increase of 153 over the number installed in 1924.

While the number placed in service in 1926 exceeded the two previous years, the actual number of locomotives owned on January 1, 1927, totaled 62,428 or a decrease compared with January 1, 1924, of 2,468 locomotives. Despite this decrease in the number of units, the average tractive power per locomotive at the beginning of this year was approximately 6.7 per cent greater than three years ago.

Class I railroads on January 1 this year had 329 locomotives on order compared with 471 one year ago and 287 on January 1, 1925.

Freight cars installed in service in 1926 totaled 104,000, which was a decrease of 24,422 compared with 1925 and 52,414 compared with 1924. Of the 104,000 freight cars installed last year, box cars numbered 46,063; coal cars 41,084 and refrigerator cars 8,471.

While the number of freight cars owned on January 1, 1927, was an increase of 28,473 cars or 1.2 per cent compared with January 1, 1924, the average carrying capacity per car on January 1, this year, was 45.3 tons compared with 43.5 tons three years ago or an increase of 4.1 per cent.

Reports showed 21,242 freight cars on order on January 1 this year compared with 40,794 on the same date last year and 55,684 on the same date two years ago.

These figures as to freight cars and locomotives include new and leased equipment.

Economic Advantages of the Roller Bearing and Locomotive Booster

By Wilson E. Symons

One of the major items of expense in railway operation is the locomotive fuel used in train movement. Approximately 15,000,000 trains per year, or an average of about 41,000 per day, are moved on our railways. Fuel to the value of $417,552,715 is required to move these trains and it represents 9.04 per cent of the total operating expenses of railways.

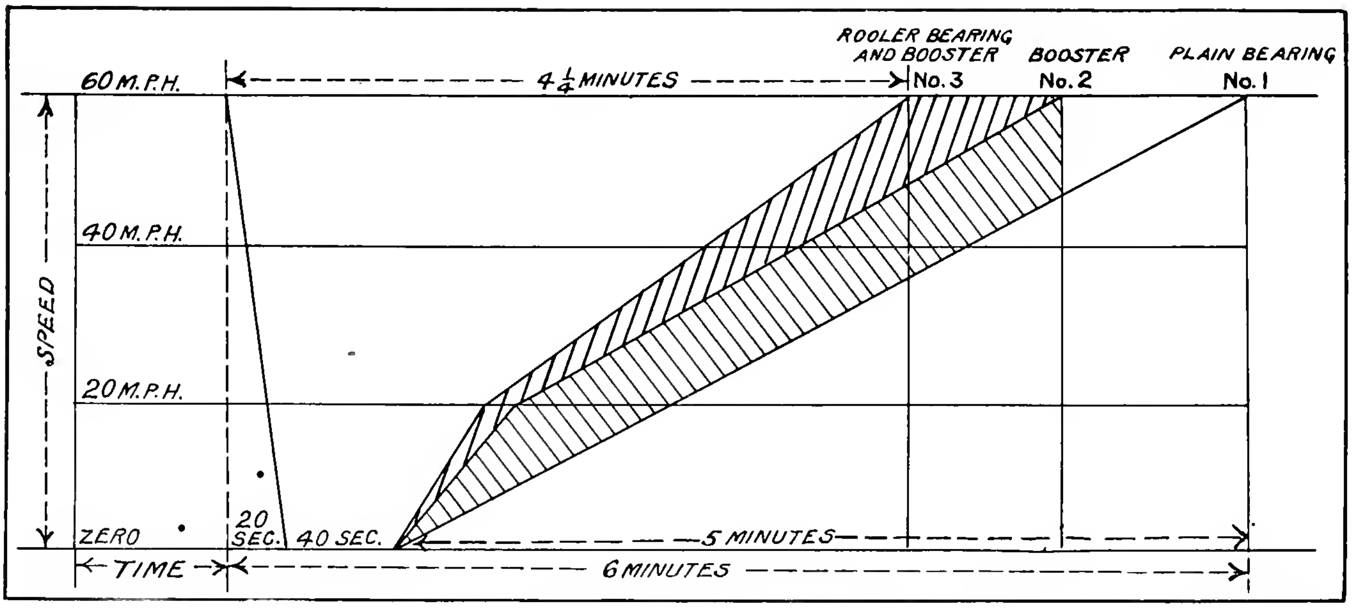
It is therefore plain to all, that any improvement in the design of the equipment used, or practices in operation that result in either economy in the cost or improvement in the service, should be sought by those in authority with the view of still raising the standard of both equipment design and operating efficiency.

Many thousands of dollars' worth of fuel is extravagantly used, if not actually wasted, in starting trains from terminal and other points where stops are made and also by slow dragging of heavy tonnage trains over the peak or tops of adverse grades. The loss of fuel from engines slipping, or when overworked in an effort to avoid stalling on a hill with a heavy freight train, or in accelerating passenger trains to schedule speed from a state of rest, particularly in heavy local and suburban service is apparent.

Therefore, since effective remedial means are available one is inclined to wonder why they are not generally adopted in view of the economic losses in fuel wasted and that the slowing down of the complete unit is due to the limits of engines' capacity. The situation can and has been remedied by the use of an auxiliary engine or locomotive booster, which at once makes a larger or more powerful engine out of one, which without this additional device, was too light for the requirements of the service in which it may be used.

With the improved conditions resulting from the auxiliary locomotive or booster to increase engine capacity, it must be borne in mind that one of the most important elements in starting trains is the resistance due to journal friction and that until quite recently very little progress had been made in this country to effect any improvement in this direction, although tried out and tested roller bearings have been for a long time available.

In the November, 1926, issue of this publication there appeared an article describing the application of roller bearings to 127 cars on the Chicago, Milwaukee & St. Paul Railway. These cars are to be used in through trains between Chicago and the Pacific Coast. In the article referred to, the reduction in train resistance due to journal friction with cars equipped with anti-friction bearings was there shown in a comparison made between cars so equipped and other cars equipped with the plain A. R. A. bearings. While the figures given as to the resistances developed with the plain bearing equipped cars were rather high, when compared with the results obtained in other tests where comparisons between the two types of bearings have been made, nevertheless, although a large expenditure was involved, the change from plain to roller bearings seemed justified.



This Chart Shows Hypothetically the Time Involved in Stopping, Starting and Accelerating to Running Speed the Common Standard Train as compared with One Equipped with a Locomotive Booster and Also One Equipped with a Booster and Cars with Roller Bearings

However, such changes can only be decided and approved for any particular carrier after an impartial investigation, in which all the physical characteristics of the property and operating condition are considered. These must be fairly appraised and considered in connection with engineering and finance, so that no avoidable mistakes may be made.

In all matters of this kind there will be found those that either overestimate or underrate the merits of this, that or the other plan. After making full allowance for differing opinions, actuating motives, etc., there seems to be no question but that this feature of equipment design has been sadly neglected, and that anti-friction journal bearings offer a most inviting field for improvement in rolling equipment.

The auxiliary locomotive, or booster accomplishes wonders in the way of increased engine capacity, particularly at a time and place where it can and is used to the greatest possible advantage. It thus saves the expenditure of great sums of money for new and larger main-line-power, or switch engines to serve as helpers. However, it is obviously limited as to period of time and rate of speed within which it functions, while the roller bearing never ceases to operate while the unit of equipment is in motion.

In another column of this issue will be found an article in which roller bearings are shown to have been applied to an auxiliary locomotive, commonly called a booster.

A Hypothetical Chart

In order to emphasize the value of the auxiliary engine, or booster, and also the use of roller bearings, we invite attention to the accompanying graphic chart, which shows a hypothetical case of the division of time of a heavy local passenger train in making regular station stops.

The total elapsed time in making a station stop varies from 3 minutes to 7½ minutes, depending on the kind and volume of the traffic and also the physical characteristics of the railway equipment, etc. In the case cited in the chart, a total of 6 minutes is expended in bringing the train to a full stop from 60 miles per hour, handling the station's business, and again accelerating the train again up to a speed of 60 miles per hour, although the principles embodied in the chart may be readily applied to many variations of conditions as to the time element, and the other factors involved.

It is most interesting to note that, as the result of the use of an auxiliary locomotive, or booster, the train is so quickly accelerated into speed from a state of rest up to 20 miles per hour, that the full attained speed of 60 miles per hour is shortened from 6 minutes to 5 minutes, or more than 16 per cent. Therefore, on a heavy local passenger run with say 30 stops, an engine that has been losing 15 to 20 minutes' time each trip, could easily be made to make the schedule with the aid of an auxiliary engine, or booster, with time to spare, and thus save the purchase price of a new engine. Similar advantages obviously would result in freight service in starting heavy-tonnage-drag-trains out of yards or to prevent stalling on the peak of grades. This would save an investment in switch engine or helpers on grades, plus the expense of operating the separate unit.

Roller Bearings on Passenger Cars

The very marked reduction in train resistance due to use of roller bearings in place of standard A. R. A. plain bearings is also clearly brought out in the graphic chart. Special mention, however, should be made of the fact that roller bearings function in the reduction of frictional resistance of units to which they are applied at *all speeds* and at all times. The auxiliary locomotive or booster only functions up to a speed of about 20 miles per hour. This feature is illustrated by the speed lines on the chart from zero to 60 miles per hour.

The total time involved due to station stop; including decelleration, stopping, standing still, and again starting and accellerating the train to a running speed of 60 miles per hour is 6 minutes without booster or roller bearings. With plain A. R. A. bearings with the use of the booster or auxiliary locomotive however, the time of accelleration is reduced from 5 minutes to 4 minutes, or 20 per cent. If roller bearings were on the cars, the combined time of accellerating the train to the running speed would be reduced from 5 minutes to 3¼ minutes, or about 35 per cent.

Both the auxiliary engine, or booster and roller bearings, will be growing factors in economic train operation if for no other reason than that they help the time element in starting a train from a state of rest and accelerating it to schedule speed.

Baltimore and Ohio Centenary

The first formal function in connection with the celebration of the One Hundredth Anniversary of the Charter by which the Baltimore & Ohio Railroad Company came into being, will take place in Baltimore, February 28th, when a dinner will be held at the Lyric Theatre. Invitations for this occasion will be sent to some eight hundred persons.

Daniel Willard, president of the Company, will preside at the dinner. Adresses will be made by Hon. Albert C. Ritchie, Governor of Maryland; Hon. Howard W. Jackson, Mayor of Baltimore, and Hon. Newton D. Baker, of Cleveland, a director of the Baltimore & Ohio, and formerly Secretary of War during President Wilson's administration.

For months the Baltimore & Ohio management has been considering plans to celebrate befittingly this year the Centenary of the Company. It was found that it would be necessary, in order to give ample opportunity for all to share in the enjoyment that such ceremonies would afford, to hold the chief functions of the celebration at a time of the year when weather conditions would be favorable for outdoor festivities. The chief exhibitions, pageants and other forms of the Centenary celebration will be held during the latter part of the Summer and early Fall, probably extending over several weeks.

As weather conditions are not propitious in February, the twenty-eighth day of which marks the One Hundredth Anniversary of the Charter, it was deemed inadvisable to undertake any extensive program at that time; but, as the granting of the Charter by the Maryland Legislature on February 28, 1827, marks the day of the Company's birth, the Management felt that it would be remiss were it to let the hundredth anniversary of that historic event go by unobserved in some special manner and concluded that an approprfiate way to honor this occasion would be to hold an indoor function such as is being arranged for the night of February 28, 1927.

The significance of the date should not be minimized. The Charter granted by Maryland in 1827, now a hundred years old, is the one and the same under which the Baltimore & Ohio continues into its second century.

It will be recalled that the Maryland Legislature of 1924 authorized Governor Albert C. Ritchie to appoint a Commission to represent the State of Maryland in co-operating with the Baltimore and Ohio in the Centenary celebration. This Commission consists of Holmes D. Baker, of Frederick, Md.; Oliver H. Bruce, Jr., of Cumberland, Md., and Van Lear Black, Alexander Brown, Jacob Epstein, John W. Garrett and George Weems Williams of Baltimore.

For the occasion of the dinner the Management is working on some special plans which, it is believed, will mark it as unusual in interest and entertainment. In addition to the customary program, there will be presented some historical matters relating to the early days of the Baltimore & Ohio in a unique way.

American Firm Sells Russian Railway Cars

An American firm has sold to Mr. A. I. Kagan, a Soviet citizen, 976 complete sets of four-wheel box cars comprising metal component parts, with the necessary galvanized roofing, at present stored at Seattle. These cars were originally built in the United States for the Russian Government Railways, but on account of the troubles in Russia were never sent from Seattle, where they have been lying in storage for several years. It was the original intention to sell these cars direct to the Chinese Eastern Railway, but conditions were such that the firm could not wait for the Railway Administration to decide whether or not it would buy these cars.

Anti-Friction Bearings for Heavy Duty on Railway Rolling Stock

A Description of the Application of Roller Bearings to the Bethlehem Auxiliary Locomotive

The Bethlehem auxiliary locomotive is a tractor tender truck which utilizes the non-revenue weight of the tender to obtain additional power for starting, accelerating, and for operating at low speeds on ruling grades. Developed on the Delaware & Hudson, and later acquired by the Bethlehem Steel Company, it is now in freight service on a number of railroads throughout the United States. A complete description of this locomotive auxiliary was published in the issue of *Railway and Locomotive Engineering* for July, 1923, but the one there described had plain bearings.

However, in the light of the present, and the increasing interest of railway men in the possibilities of anti-friction bearings, the application of roller bearngs on these engines that were built subsequently is worthy of more than passing notice. Serving both the functions of dead load carrier and driving medium, it possesses, from the standpoint of load-carrying capacity and severity of service, the most exacting requirements which the anti-friction bearing has yet attempted to meet in railway service. More than three years ago twenty-nine auxiliaries so equipped were put in service on two railroads. The service record of the bearings has been characterized by freedom from mechanical difficulties, and it has clearly demonstrated their ability to function satisfactorily under heavy duty railway service. Viewed from the operating standpoint, there appear to be some attractive possibilities for this design of bearing to other types of equipment.

The following describes in detail the construction of the bearing and journal box:

The construction of the spherical journal bearing is shown by the accompanying cuts and diagram and are the development of the SKF Industries, Inc.

The earlier trials of ball bearings on railway rolling stock showed clearly the limitations of the existing types of anti-friction bearings, and the experience thus gained served as a basis for the development of this design of bearing. The requirements of first importance in its design were: (1) maximum load carrying capacity within minimum external dimensions; (2) ruggedness and the ability to withstand heavy shock loads; (3) self-alignment. The bearing itself is a self-contained, non-adjustable unit. When mounted on the axle, the single bearing carried the combined load on the journal, the lateral thrust, the traction and braking reactions and uniformly distributes these forces over the two rows of rolling elements.

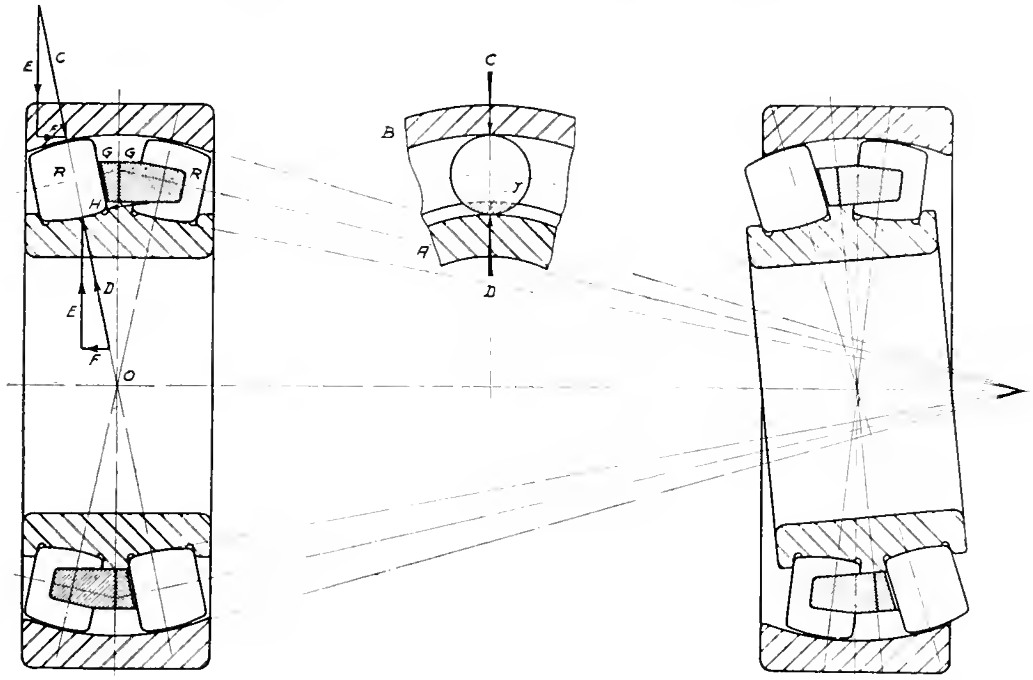
A cross-sectional view is shown. The inner race (A) is rigidly secured to the axle either by means of a tapered sleeve or a press fit. The outer race (B) supports the journal box and is in contact with it over an accurately finished surface in the crown of the box. The rolling elements (R) are barrel-shaped and it will be noted that they have a broad point contact on the outer race and a line contact across the inner race. The curvature of the outer race is towards the roller, and the curvature of the inner race is away from the roller. Under load, elastic deformation takes place where the races and rollers are in contact, and hence to properly apportion the contact stresses on the rings and the two ends of a roller diameter, the broad point contact is given to the outer race and the line contact to the inner race.

The inner surface of the outer race is the surface of a sphere generated with the center of the bearing (O) as its center, and giving the bearing its self-aligning property. It is evident that the rolling elements are free to move around the surface of the sphere without losing their normal contact, and without changing the distribution of load on the rollers and races.

Locomotive Tender Equipped with Auxiliary Locomotive or Booster That Is Fitted with S K F Roller Bearings and Manufactured by the Bethlehem Steel Company

As shown in the figure, the contact diameter, or greatest diameter, of the roller is not its mid-diameter, the proportions being obtained from considerations of capacity.

The plane of the resultant load on the races and rolling elements is inclined to the journal axis as shown at (C) and (D). This angular contact enables the bearing to carry both radial loads and axial thrusts, each rolling element in a given row carrying its proportionate share of the thrust.



Cross-Sectional View of S K F Roller Bearing

The two special alloy bronze retainers GG are independent of each other and they abut back to back. They serve to keep the rolling elements properly spaced and are subjected only to such stresses as result therefrom. They do not ride on the rollers, but are carried on the ground surface of the inner race land. The roller pockets in the retainers are milled cylindrical in form. There is a shallow filling notch in each of the lands at the sides of the inner race which enables the rollers to be inserted when assembling the bearing. The rollers are specially selected to assure that they exactly conform to the contour of the inner race, by spotting them with bluing and noting the corresponding line where they contact with the inner ring.

The bearing can be taken apart by deflecting the outer race and removing two rollers from one row and then from the other; after turning the inner race so that its axis makes 90 degrees with that of the outer, the inner race can then be readily lifted out.

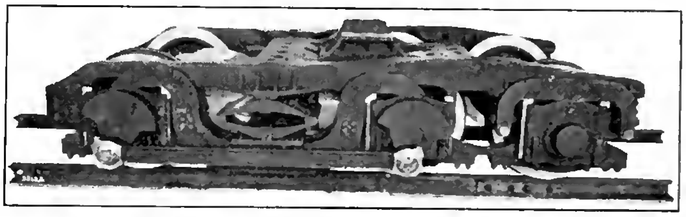
Precision in manufacturing is necessary in the making of the bearing, and all of the steel parts are accurately ground all over. It is interesting to note the method employed for guiding the rollers. Their inboard ends are surfaces of spheres of a very large radius. The two sides of the inner race land are spherical surfaces of the same radius, both accurately ground. The contact between the roller ends and the sides of the inner race lands (shown at J), is of basic importance in the functioning of the bearing, because it maintains accurately the alignment of each rolling element and insures that normal line contact with the inner race which is essential to obtain true rolling contact and consequently, maximum capacity.

All of the parts except the retainer are made of high-grade carbon chromium steel hardened throughout. The carbon and chromium contents will, of course, vary approximately inversely and directly as the ring size in order to obtain this result. In heat treatment both water and oil quenching of the rings are used.

In the design of the bearing the theoretical requirements for true rolling contact have been kinematically satisfied. Practically, the only deviation therefrom is that which must obtain in any anti-friction bearing, and which is due to the deformation at the contact areas under load. Its effect in this case is negligible and in a properly designed and lubricated railway application there is no perceptible wear of the bearing parts. This may appear to be a very broad claim, but it has been proven through repeated examination and measurement of many bearings in service.

The bearing as applied to the journals of the auxiliary locomotive is shown by the accompanying cross-sectional assembly. It is mounted between the wheel and the overhung crank. The journal is accurately ground to size to assure its being round, smooth, and free from taper. The spacing collar between the axle shoulder and the inner race is a tight fit on the axle, as is the inner race, which is shrunk on after heating in oil to approximately 200° F. It is further secured by the lock-nut against which the crank is pressed or shrunk on. No occasion is necessary to provide for subsequent removal since the wheel of the auxiliary are steel tired and the centers very rarely have to be replaced.

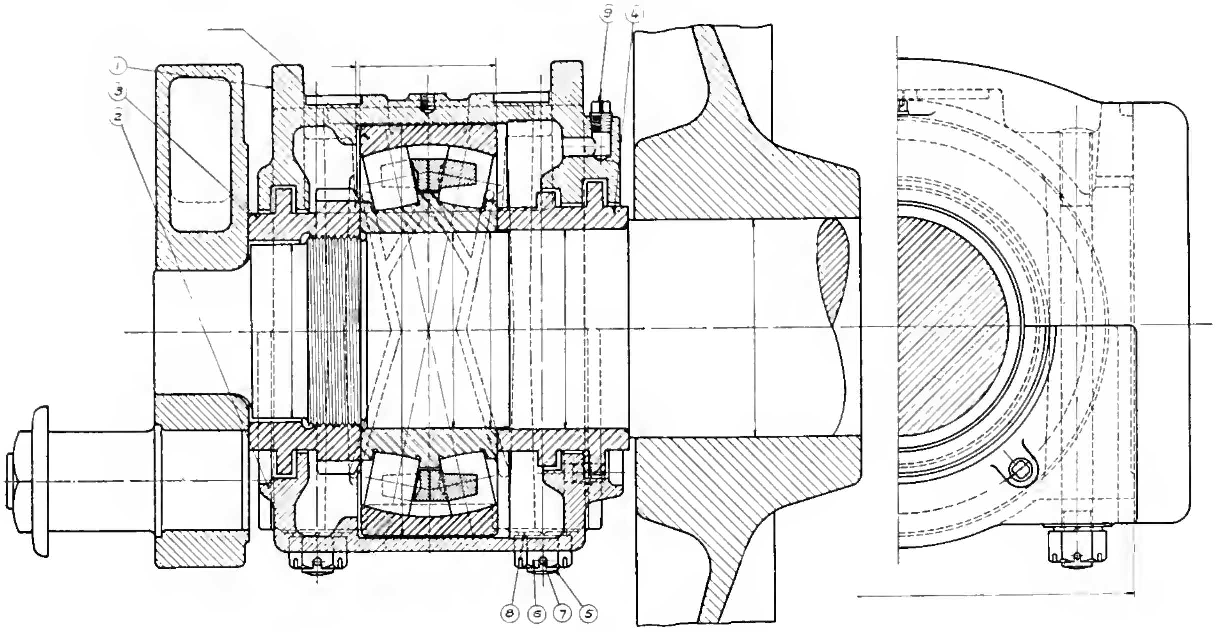
The journal box is made in two pieces somewhat after the manner of the conventional locomotive driving box, and is of electric furnace or open hearth cast steel. The two parts are secured together by studs and castellated nuts. The lower part acts as an oil cellar; it is relieved in the bore and serves merely to house the bearing and retain the lubricant which in all cases should be a high grade cylinder oil. The upper part of the box is very rugged in its construction. The dead load is applied on the top through two equalizer bars spaced on either side of the bearing, an arrangement which affords lateral stability to the box. It is ground in the bore to accurately fit the outer race over an arc of approximately 180 degrees. An accurately ground surface is important here for several reasons, viz.; (1) to prevent a concentration of load over a small area of the ring; (2) to enable the bearing to slide



Six-Wheeled Tender Truck Equipped with Bethlehem Auxiliary Locomotive and S K F Bearings in the box under the lateral thrust on the axle; (3) to permit of creeping of the outer race.

The labyrinth seals on each side prevent the oil from being thrown out, and dust and dirt from getting in. Filling and drain plugs are provided to facilitate the application and renewal of the lubricant. The proper oil level is at the center of the lowest roller and there is a plug located at this level.

Every effort is made to be sure that the inside of the box is clean, and to further this end the castings are sandblasted and the non-machined interior surfaces are coated with heavy shellac or an aluminum paint.



Side Elevation and Cross Section of S K F Roller Bearing As Applied to Tender Booster of the Bethlehem Steel Company

As is customary with locomotive driving boxes the faces are grooved for lubricating purposes, but it is worth pointing out that the flanges are machined straight, and are not tapered in toward the horizontal center line in the usual manner. This is unnecessary, since the self-aligning property of the bearing affords complete flexibility to the axle. As pointed out above the box is stabilized by the application of the load through double equalizers rigidly connected together. At the present time, shoes and wedges are used on the pedestals, but it is believed that experience will show that these are not necessary.

The thrust on the axle is taken through the outboard row of rollers, against the thrust shoulder in the box. In the opposite direction the thrust is carried in the same manner by the bearing on the other end of the axle. The outer race has a float of 1/16 inch in the box, and the box ⅛ inch in the truck pedestals. This gives a total of 3/16 inch on a side, or a total lateral for the axle of ⅜ inch. This is a constant quantity according to design, and within limits it can be made whatever is desired.

A few figures on loads, weights, and dimensions of this journal bearing should prove of interest:

Dead load, with fully loaded tender........	28,000 lbs.
Side rod thrust, with engine developing maximum power	28,000 lbs.
Maximum Combined load on the bearing..	40,000 lbs.
Plain bearing journal size................	8½ x 16 in.
Distance—center line of journal to equalizer seats on top of box..................	9 in.
Width across the faces of the jurnal box...	18¾ in.
Weight of journal box (approximate)......	600 lbs.
Weight of bearing (approximate).........	215 lbs.

Auxiliary locomotives equipped with this type of journal bearing have been in service for more than three years, the earliest applications being on the Delaware & Hudson, and the Kansas City Southern. During this period, the outstanding characteristics of the bearing has been its reliability through which it has contributed in no small measure to the success of the unit as a whole. There have been no train detentions due either to hot boxes or other mechanical difficulties, and the bearing has given abundant evidence of its ability to meet the exigencies of service.

The bearing and journal box constitute a completely enclosed non-adjustable unit which do not require attention in service. A check on the oil level should be made at least once a month at an engine house by removing the pipe plug which is located at the proper oil level. For equipment continuously in service, the lubricant should be drained out and new oil added once every six months.

Based on the service record of the bearing, and giving due consideration to the known factors which affect bearing life, an inspection of the bearings once a year is deemed all that is necessary. The characteristic failure is due to fatigue of the metal and it appears in the form of a flaking or spalling of the load carrying surfaces. After it makes its appearance, it develops very gradually; it is a chronic, rather than an acute condition, and as such, yearly examinations will show it before it develops to a serious extent. The other possibilities are defects in workmanship or material, or those resulting from abuse in mounting. From the standpoint of capacity and ruggedness of construction the design is such that, should any of these defects appear, they will not, in the time between inspections, grow to such a point as to precipitate a bearing failure that would cause a detention or damage to equipment. Originally, it was considered necessary to make these examinations quarterly, but the present yearly examination is now held to be sufficient. This program is aside from accidents or derailments. There have been several cases where the bearings underwent derailments without sustaining any damage, but should such occur, an examination should be made before returning the equipment to service.

The inspections which have been referred to above can be made at the regular shopping periods and do not involve removal of the bearings from the axles. It is merely necessary to remove the boxes and wash the bearings with gasoline, after which all parts and load carrying surface can be examined by deflecting the outer race.

The Atlantic or 4-4-2 Type Locomotive

By Arthur Curran

Of all the types of locomotives which have survived from an earlier epoch, the Atlantic presents about the most puzzling problem today. In point of size and weight, some examples of the 4-4-2 type are equal to certain classes of power which have many years of usefulness ahead of them; but in tractive power and general availability, few of the Atlantics are suitable for modern service. Express trains are too heavy for them and local trains require engines capable of quicker acceleration and all-round liveliness. This leaves the Atlantic in much the same position as that of the man who was divorced by his wife, and refused by the next girl to whom he proposed!

It is more than thirty years since the Baldwin Locomotive Works introduced this wheel arrangement; and, though many examples have been built during that period, the type has not at any time enjoyed an easy popularity. In its early days, it had to compete with the American type—then in all its glory!—and in less than a decade was confronted with the much more powerful Pacific type. The latter swiftly thrust it aside, and has retained a proud pre-eminence ever since.

With the exception of the Atlantics built for the Philadelphia & Reading and for the Central Railroad of New Jersey, most of the early examples of the type had a long and narrow firebox. In due course, both the Lehigh Valley and the Pennsylvania tried the Wootten firebox or a modification thereof. Finally, the majority of roads settled upon a style of firebox which afforded ample depth and width while allowing the cab to remain in the orthodox location.

Having but two pairs of drivers, the Atlantic did not develop a very amazing tractive effort, but its boiler capacity gave it a greater reserve of power at high speed than the American type had; and, hence, enabled it to handle heavier loads on long runs.

In the meantime, the Atlantic type had been introduced in England, the honor going to the Great Northern Railway, which built the first example in 1898. This had a narrow firebox, as did a number of others of the same class. The G. N.—which is now part of the London & North Eastern Railway—ultimately brought out a class of Atlantics with the Wootten style of firebox, and these engines were for many years the most popular on the road. Their cylinders were very small, however, in proportion to the possibilities of the type.

The 4-4-2 design which appeared in 1899 on the Lancashire & Yorkshire—now part of the London, Midland & Scottish—was really nothing more than a 4-4-0 of the period, modified as to wheel arrangemtnt It had inside cylinders; and, though the boiler was perched above large coupled wheels, it was not notable either as to size or heating surface.

Upon several other British railways the Atlantic type achieved a place, but most of the examples lacked the elements of design which brought the type whatever success it enjoyed in America.

It remained for the little "Brighton"—London, Brighton & South Coast—to bring out a class of Atlantics which, in point of cylinder dimensions, was comparable with the average American practice of the period. There are only eleven engines in this class, but they are worthy of some notice. The cylinders are 21 x 26 inches, drivers 79 inches in diameter, boiler 66 inches in diameter, working pressure 170 lbs. per sq. in., and grate area 30.9 sq. ft. Weight of engine and tender 107 tons.

It will be noted that the grate is not large, judged by American standards; but it has the correct proportions, being short and wide, instead of long and narrow. In this manner, it makes the best use of the space back of drivers and over trailing wheels.

Prior to consolidation with the Southern Railway, the Brighton presented some rather perplexing motive power contrasts, as passenger trains might be hauled by anything from an Atlantic to a tank! Occasionally, also, 4-4-0 engines were used. The present policy appears to favor the 4-6-0 type, on account of the latter's all-around usefulness.

An Atlantic Type Locomotive, the E-6-S Class, on the Pennsylvania Railroad

In England it will be possible to find some use for existing Atlantic engines. The type is not being built any more, either in that country or America; but it is in the latter that the problem is the most difficult.

4-4-0 Type Locomotive of the London, Brighton & South Coast Now the Southern Railway of England

There is one exception; this being the remarkable Class E-6-S of the Pennsylvania. An Atlantic engine which develops 31,275 lbs. tractive force is certainly an amazing locomotive, even in this age of wonders! Mr. Charles B. Chaney has made a survey and study of the work done by certain of the engines belonging to it. He found that, on low grade divisions, the E-6-S handled trains of a weight and schedule equal to those handled by Pacific type engines on other roads. This means that 14 steel cars were taken over such divisions at a speed of 60 m.p.h. or better. Of course, the schedules do not "work out" at that speed; but it is well known that station delays, slowdowns and adverse signals use up an amount of time which can be regained only by running at a very much higher rate of speed than appears on the time-card.

Some of the most interesting work done by these engines was on New York-Washington trains, which must face a rather stiff grade at London Park. With the heaviest of them, an E-6-S would be making 40 m.p.h. at the summit. Such a train is shown herewith, hauled by engine 779.

The very great weight on drivers of this class would bar it from some roads, but the design remains one of the seven wonders of the world, any way you look at it!

As for the majority of Atlantic engines in this country: The scrap heap has awaited them these many moons, and will get them if their owners have any sense. Certainly, they are good for nothing; not being even as adaptable to changing conditions as a 4-4-0 in fair condition. The ordinary "garden variety" of Atlantic is too "slippery," anyhow, to get over the road, except with a light load and infrequent stops. Moreover, it costs more to run and maintain than a smaller engine capable of doing the same work.

Inasmuch as the Pacific type is supreme on low-grade lines and the Mountain type on hilly roads, the Atlantic is superfluous. Local passenger runs will be taken care of by 4-4-0 engines—while they last!—Moguls, ten-wheelers, electric trains or motor cars. (Rail type.)

Briefly stated, the main fact is that the four-coupled age is definitely in the past, and that the six-coupled age has taken its place. I refer, of course, to passenger service.

For the benefit of those who may be interested in the English Atlantic, a photograph of a Brighton engine is presented herewith. Of course, since the picture was taken, this class has been painted the sage green of the Southern Railway, and lettered and striped accordingly.

Recent Locomotive Developments*

By W. E. WOODARD, Vice-President, Lima Locomotive Works, Inc.

Even a casual study of the growth of American railways during the past twenty years develops many subjects of interest to the engineer. During this period the railways have, to a notable degree, made use of the products of scientific and engineering research for the improvement and more efficient use of their transportation plants, and thus any study of our railways leads at once into the field of engineering.

In such a survey of rail development, one fact stands out prominently: that, while main line track mileage has not materially increased during the past twenty years, there has been an enormous increase in the amount of business handled, and that the railroads have only been able to handle this increase by vastly increasing the traffic capacity per mile of track operated.

In this traffic expansion the advance in steam locomotive design has contributed its full share by increasing the size and speed of trains, and has been the largest single factor in making this expansion possible. It would be an interesting story did time permit tracing the evolution of the locomotive from "The Rocket" to the modern power plant on wheels. The modern locomotive contains the same essential elements as "The Rocket"—an internally fired steam boiler, cylinders and wheels, but this combination unaided by the developments which steam engineering has produced since Stephenson's time would be ludicrously inadequate for our requirements.

Superheating, feedwater heating, mechanical stoking and high boiler pressures, all helped in this evolution. They have largely made possible the production of locomotive designs capable of meeting modern traffic conditions. Fine locomotives were being built embodying these and other improved features of design and were bettering by large margins the performance of typical locomotives of ten or fifteen years ago. However, it was becoming apparent to students of locomotive engineering that we had about exhausted the possibilities of these combinations for further improvement, particularly as we were up to the limits of wheel loads and physical clearances in almost all of our locomotives. This was the reason for starting the series of tests and experiments which I will explain for you and by which we hoped to find ways to still further advance the locomotive art.

The natural approach to this problem was a survey of the trend of operating requirements. The increase in the volume of traffic moved over each mile of main line track per day was accomplished by moving heavier trains faster, which, expressed in terms of units familiar to you all, is an increase in gross ton miles per train hour.

The increase of 123 per cent in gross ton miles per train hour in the past twenty years means that there has been a proportionate increase in the power output of the locomotives required to do the work. The power output of the locomotives is not exactly proportionate to the increase in gross ton miles per train hour, as factors such as better signaling and train operation have had some effect. However, without going into an extended analysis of these figures, it can safely be stated as a fact that the increased power demands upon the locomotive during this period are nearly proportional to the increase in gross ton miles per train hour and which as stated, approximates 123 per cent.

Power output demands steam and steam requires coal for its production. Thus, logically, the first step towards improving locomotive designs led to a study of combustion conditions in road service. It had been apparent for some time past that we were reaching a very definite limit in steam generating capacity of our locomotives, because of the fact that the firebox and grate area set a limit to the amount of coal that could be burned and, in turn, the size of grate was fixed by the weight which could be carried on one trailer axle. Moreover, the trailer axle generally had to carry a stoker, a heavier ashpan and often a booster.

An example will illustrate what I mean by the firebox and grate limitation. A railroad came to us with this problem. It was necessary for them to use two Pacific type engines over a certain part of their line in order to make the schedule of their through passenger trains. They wished to get one locomotive capable of doing the work. An analysis of the power output required to pull the train and a study of the proportions of the locomotives revealed this fact: that, while the cylinders of one engine were capable of developing the required power, the grate and fire box was totally inadequate to generate the amount of steam needed for the power output. Two engines had to be used in order to get a combined grate area sufficient to produce the steam required to pull the train, even though the cylinders on one engine could pro-

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*Abstract from a paper presented to the Western Railway Club.

duce the power. The size of the grate and firebox absolutely limited the work which these locomotives could do.

It is familiar experience to most of you to see a locomotive, when being pushed hard, reach a point where it seems to quit. It really does. The firebox has reached the point where it simply cannot digest any more fuel, and no additional power can be coaxed out of the locomotive irrespective of how much coal is fed to the locomotive furnace.

Thus you will see the logic of going after the combustion situation in locomotive designs. Cylinder proportions might be increased, steam pressure raised, driving wheels added, but to what avail if the grate is not made big enough to burn the coal necessary to produce the steam demanded by the increasing gross ton miles per hour. This was the reason for the introduction of the four-wheel trailing truck.

Tests showed that with a grate area of 66.4 sq. ft., an average Mikado locomotive boiler has a maximum capacity of 65,520 lb. of steam per hour, while the Lima A-1, 2-8-4 locomotive boiler with a grate area of 100 sq. ft., and burning the same amount of coal has a maximum steam capacity of 74,450 lb. per hour. These tests and experiment studies were directed to an investigation of the combustion conditions in locomotives; they were concerned with the steam producing portion of the locomotives. What follows relates to our studies of the steam using portion, i. e., the cylinders and machinery.

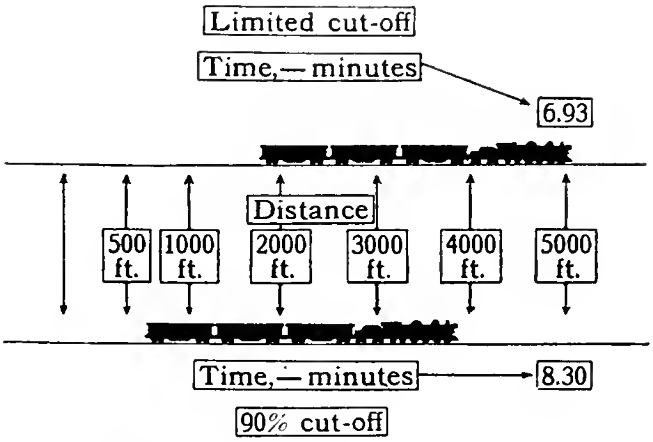
For years various attempts have been made to improve the efficiency of the engine cylinders in using steam. Superheating made the greatest advance in this direction by reducing cylinder condensation and thus saving steam. Compounding and uniflow cylinders represent less effective efforts in the same direction. Limiting the maximum cut-off in the engine cylinder was being practiced by one large railway system and without doubt was reducing steam consumption. It did this because limited cut-off run at a shorter average cut-off than full-stroke engines and thus secure the advantage of a more expansive use of the steam. While the economy of these locomotives was well known, the possibilities of the limited cut-off scheme for increasing the power output per unit of driving wheel weight did not appear to be recognized.

When we began to consider the use of limited cut-off as a means of improving locomotive design, there was one question about its use which was not fully answered; namely, would a locomotive with limited cut-off get away as quickly and accelerate a train as rapidly as a full stroke locomotive of equal starting effort? Possibly the sound of a full-stroke locomotive pulling its train out of a station to led some to believe that it would accelerate faster than the less noisy, and thus, apparently, less energetic, limited cut-off locomotive. The answer to this question is given in one of the drawings.

The use of limited cut-off necessarily involved heavier piston thrusts, because more power is being produced from a cylinder of given size. This led, logically, to a study of rod and pin conditions. No elaborate data is needed to convince this audience that the conventional design of locomotive rods and pins has reached, if not passed, the limit of power which this construction can carry. Various cures for hot pins and brasses, like floating bushings, are used, but they do not get at the root of the trouble. The cause is not removed; the effect is only made less troublesome.

And thus it was in 1924 we made a set of experimental rods and tested out in service a new scheme to remove the design limitation set by the conventional rod drive by transmitting the piston thrust to driving wheels back of the main wheels without having to go through the main crank pins. Service test showed that the new rods ran successfully and met all road and maintenance conditions. This form of rod drive has now become familiar to you. It is in use on about 150 locomotives in this country and is also being tried out in England.

I have pointed out the vital importance of power output in locomotive design. As weight limits have remained about stationary and as the boiler and firebox are the primary sources of power in a locomotive, it naturally follows that if we can reduce the weight of any of the parts outside of the boiler and put that weight into the boiler we will be increasing the power output by the amount of boiler added.



Increased Acceleration with Limited Cut-Off

Until 1924 little had been done with cast steel locomotive cylinders. As many of you know, steel cylinders had been made, but their use was certainly not encouraged by the producers of steel castings. With the help of the Ohio Steel Foundry Co., we produced a cast steel cylinder design which overcame the objections of the foundry people, and to try out its practicability a set was made, machined and tested. The weight saving was more than 4,000 lb. per pair of cylinders over those made of cast iron. Large numbers of this design of cylinder have been produced and there now appears to be very little difficulty in getting either this or the conventional design in cast steel.

After these studies and experiments assured us of the correctness of our ideas, the various elements were combined and developed into a complete locomotive design, which one of the large railway systems of the country had the enterprise and courage to assure us they would try out. The engine was built and the design is now represented by 105 locomotives in service. To what degree the design has met expectations can best be shown by its accomplishments.

As the data are shown and some of the details illustrated, I would ask you to notice that these results have been obtained by the co-ordination of existing and well tried elements of design. To be sure this locomotive is more complicated than the engine of a few years ago, but what machine can be mentioned that has not become more complicated as its range of usefulness and accomplishment has been extended?

While I do not remember having heard the term "full-jeweled" applied to this locomotive, it has been used to describe many modern designs by persons who evidently failed to grasp the significance of the engineering advance represented by what they were pleased to call "jewelry." It is evident that as the requirements of safety, rapidity, and efficiency of operation, as well as the amount of work to be done, advance, machinery to meet these requirements becomes more complicated. The intricacies of the New York subway car are relatively great, but it represents the most intensive, safe and economical transportation in the world.

And now, as to the performance of the locomotive, the picture of whose development I have sketched for you step by step as we worked each out. After breaking in the A-1 on the Boston and Albany R. R., extensive dynamometer car tests were made. These results were comparable with similar tests made about one year previous with a 2-8-2 locomotive of thoroughly modern design, having type "E" superheater, feedwater heater, and booster. The comparison is of special interest, because the two locomotives had almost exactly the same driver-wheel weight. The figures used in the following table are average for a large number of runs of each locomotive. Weather conditions favored the 2-8-2, as the tests of that locomotive were run in August, while the A-1 tests were run in late winter.

Lb. Coal Per Hour	Steam Produced, Lb. Per Hour 2-8-2 66.4 Sq. Ft. Grate	A-1 100 Sq. Ft. Grate	Increase by A-1 With Large Grate Area
5000	36,200	42,000	5800 lb.
5500	39,600	45,000	5400 lb.
6000	42,600	48,000	5400 lb.
6500	46,000	51,000	5000 lb.

The range available for overload in the boiler having the big grate and firebox is evident, being made possible by the four-wheel trailer truck design. The relative usefulness of the two boilers can best be shown by the overall efficiencies of the boiler, superheater, and feedwater heater in combination. Both boilers have type "E" superheaters and are equipped with feedwater heaters of the same type; therefore, the comparison is a fair one, and by reducing the comparison to an efficiency basis the difference in steam pressure is accounted for.

Passing to the steam-using portion of the locomotive, that is, the cylinders, some very interesting comparisons were obtained showing the effect of the limited cut-off on steam consumption. As I have said, the tests of the 2-8-2 type locomotive were run over the same division as those of the A-1, with about the same train loading. The results of the limited cut-off may be summarized as follows:

AVERAGE SAVING OF 17½ PER CENT BY USE OF LIMITED CUT-OFF.

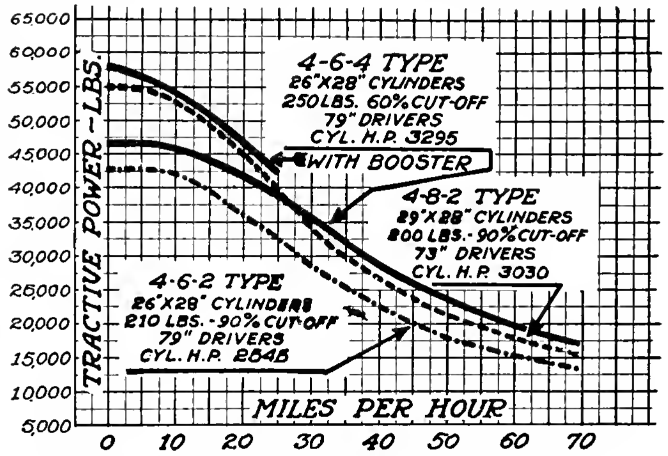
Indicated Horsepower (Avg. over division)	Total Water per Hour Lb.	Steam per I. H. P. Hr. Lb.
A-1 (60 per cent maximum cut-off)		
1800	37,400	20.8
1900	39,200	20.6
2000	41,200	20.4
2-8-2 (90 per cent maximum cut-off)		
1800	44,700	23.8
1900	46,900	24.7
2000	51,200	25.6

Thus we have not alone the saving in fuel for the same work best also the increased work which can be secured from the same amount of coal. They bear upon *economy of operation.* But we have found from many years of experience in building locomotives that while economy in fuel is a very essential consideration in any new locomotive unit, it alone is not enough. A factor of equal if not greater importance is increased capacity to pull cars.

High-pressure, limited cut-off cylinders increase the capacity of the locomotive in two ways: By raising the starting power of the engine on account of the more even torque, which permits the use of more tractive power on a given driver-wheel weight; with limited cut-off we are able to get about thirty per cent more pull at speed than can be obtained out of the same driver-wheel with full-stroke cylinders.

The tractive power which can be obtained out of this driver-wheel weight with full-stroke cylinders is very definitely set by the factor of adhesion and it is about 63,000 lb. The amount of pull at speed which can be obtained out of these full-stroke cylinders has also been well established for years past. For example, full-stroke cylinders giving a starting tractive effort of 63,000 lb. will give a pull of 34,000 lb., at 30 miles per hour, and this is all that can be obtained out of these cyinders at that speed. Now, with limited cut-off we get a starting tractive effort of 69,400 lb., but at 30 miles an hour these limited cut-off cylinders will give about 44,000 lb.

Up to the present time I have been comparing the A-1 locomotive with one of the very best Mikado type locomotives in the country equipped with type "E" superheater, feedwater heater, front end throttle, stoker, and superheat on auxiliaries. There are only a comparatively few engines of this class in the country. The majority of freight locomotives in main-line service are represented by a Mikado type having a type "A" superheater without feedwater heater and with the ordinary type of throttle in the dome; that is, the auxiliaries are operated by saturated steam. We will now show the results of actual tests of the A-1 in comparison not only with the improved Mikado which I have already used, but also with what might be called the standard type, representing a large part of freight power in the country.



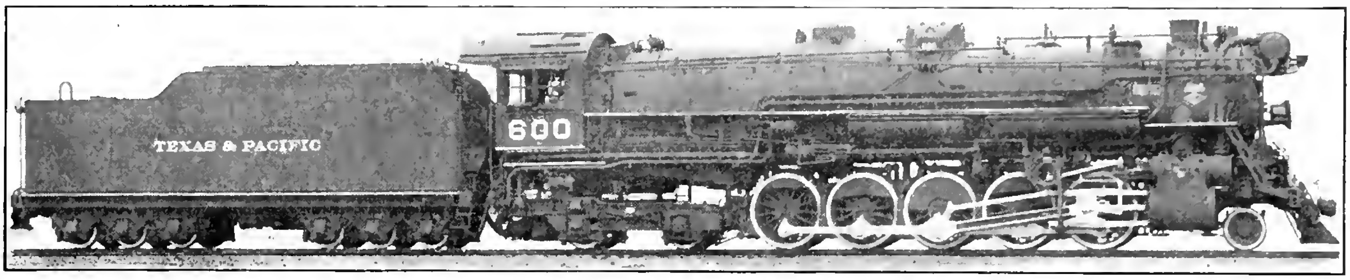
Comparison of Tractive Effort of 4-6-2 and 4-6-4 and 4-8-2 Type Locomotives of the Same Weight on Drivers

These are the two things the railroads are interested in—the coal required for producing work at the rear of the tender, that is, pulling the train, and the maximum capacity to produce power out of a given driver-wheel weight. I would ask you to note that these are not theoretical figures, but the result of road tests, a series being run upon each of the locomotives, the results shown being the average of a large number of tests. Similar results have been obtained from comparative tests in the south-west between a 2-10-4 having the same characteristics as the design of the A-1 and a full stroke 2-10-2 of good modern design. You have seen how the limited cut-off cylinders increased the power output at speeds and how we utilized the booster to add pulling capacity at low speeds, thus maintaining the increase throughout the entire speed range of the locomotive.

This increase in power over the full-stroke engine having the same driver-wheel weight corresponds very closely with the increase which can be obtained from a full-stroke cylinder locomotive having one more pair of driving wheels and larger cylinders. In other words, if this curve be true a 2-8-4 having four pairs of driving wheels, plus the booster, ought to equal in service a 2-10-2 full-stroke locomotive having five pairs of driving wheels and no booster. It actually works out this way, as is shown by the following data between the A-1 locomotive and a 2-10-2 locomotive of good modern design.

This is another verification of the fact which I have emphasized many times: namely, the use of high-pressure, limited cut-off cylinders backed up by an adequate boiler gives greatly increased power output per unit of driving-wheel weight over a full-stroke engine.

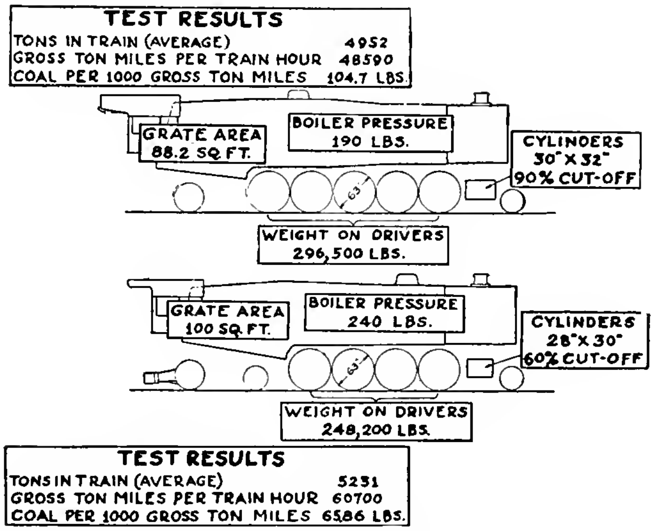
These same principles of design are applicable to any class of locomotive. For example, the following diagrams will show what happens to a 4-6-2 class locomotive when designed with cylinders capable of high horsepower output and a boiler to suit.



2-10-4 Type Locomotive of the Texas & Pacific Railway Built by Lima Locomotive Works, Inc.

In any talk where improved elements of construction are discussed, very frequently and very properly someone asks the question, "What next?" We ought to keep our minds open and always be looking ahead. In that respect, I feel that the question is a proper and desirable one. But there is one other aspect of this question—"What next" that I would like to present to you.

(Mr. Woodard here presented a moving picture showing graphically that as compared to a capacity of 100,000 gross ton miles per hour and dry coal consumption of three lb. per drawbar hp. for the A-1 type locomotive, 31½ per cent of the freight power in the country produces but 60,000 gross ton miles per hour at 5½ lb. of coal per drawbar hp. and 61½ per cent of the freight power, but 45,000 gross ton miles per hour, at 6½ lb. of coal per drawbar hp.)



Comparison of Test Results of A-1 and Modern 2-10-2 Locomotive on the Illinois Central

The discussion of Mr. Woodard's paper was opened by A. P. Pendergast, mechanical superintendent of the Texas and Pacific Ry., who stated that after an investigation of several years concurrent with the operation of three groups of well designed locomotives of the 2-10-2 type, it was decided to install high pressure, limited cut-off locomotives of the 2-10-4 or Texas type. Ten of the locomotives were delivered in December, 1925.

After a year of operation each locomotive has made about 50,000 miles of tentatively assigned mileage of 60,000. No wheels have been dropped or tires turned and inspection at the first annual test of these locomotives indicated that the flues were in good condition and there were no broken staybolts of any kind. On account of bad water and severe operating condition, the life of flues on previous types of locomotives has been limited to an average of 35,000 miles whereas the condition of the Texas type flues indicate that they will be in good condition at the run out of the assigned mileage of 60,000 miles. Notwithstanding the high piston thrust of these locomotives, rod bushing maintenance has been much lower than on the 2-10-2 type as renewals were not necessary until 24,000 miles had been run, against 15,000 miles of the 2-10-2 type. Lubrication of valves and cylinders by force feed lubricators has been entirely satisfactory.

As a summary of maintenance expense the cost of running repairs for the 30,000 mile average has been $0.194 per mile as compared with $0.273 for 2-10-2 engines in the same average condition.

The outstanding result of this design has been regularity of performance with consistent fuel savings of 41 per cent over previous types. Records indicate that ten Texas type locomotives are responsible for a saving of at least $10,000 a month in fuel alone.

Lawford Fry, metallurgical engineers, Standard Steel Works, emphasized the statement that gross ton miles per train hour was a measure of the earning capacity of a railroad and that it all depended upon the steaming capacity of the locomotive and the efficiency of its cylinders. Two features now receiving consideration were higher boiler pressures and higher ratios of expansion, such as might be obtained by compound cylinders. Some advance data was given relating to tests of Baldwin locomotive 60,000 at Altoona. This locomotive of the 4-10-2 type is a three-cylinder compound with a double drum Brotan type boiler operating at 350 pounds. The preliminary data indicate that 4,500 cylinder horse power can be developed with a combustion rate of 135 pounds of coal per square foot of grate per hour and that the cylinder water rate varies but slightly over a wide range of cylinder output. A complete report of the performance of this locomotive will be available in the near future.

Diesel Locomotive for the Boston and Maine

The Boston & Maine Railroad within a few months will add to its fast freight service twenty-six new American and German locomotives. It will obtain from the Friedrick Krupp works at Essen the first Diesel direct-drive locomotive to be operated in this country, as a trial locomotive, and specifications are being prepared for bids on twenty-five of the most modern heavy duty steam locomotives.

Railway and Locomotive Engineering

A Practical Journal of Motive Power,
Rolling Stock and Appliances

Published Monthly by
ANGUS SINCLAIR COMPANY
136 Liberty Street, New York
Chicago Office: 168 North Michigan Avenue
Telephone Rector 0746. Cable Address "Locong," N. Y.

Harry A. Kenney, Prest. and Man. Ed.
W. E. Symons, Associate Editor
J. Snowden Bell, Associate Editor.
Thomas P. Kenney, Secretary.

LONDON REPRESENTATIVE
The Locomotive Publishing Company, Ltd., 3 Amen Corner, Paternoster Row,
London, E. C. England.

SUBSCRIPTION PRICE

$2.00 *per year,* $1.00 *for six months, postage paid in the United States. Canada and Mexico. For other parts of the world,* $2.50. *Single copies, 20 cents. Remit by Express Money Order, Draft, Post Office Order or Registered Letter.*

Mailing address can be changed as often as necessary—always give old and new address, and if you subscribe in a club, state the name of the agent.

Please give prompt notice when your paper fails to reach you regularly.

Entered as second-class matter January 15, 1902, at the post office at New York, New York, under the Act of March 3, 1879.

Modern Locomotive Development

In 1924 there was placed in service on the Delaware & Hudson Railway the high-pressure, cross compound locomotive which was named the "Horatio Allen," and which had been built to the designs of Mr. John E. Muhlfeld, consulting engineer of the company.

In another column of this issue will be found a discription of a further development in high pressure locomotives, which has been brought out by Mr. Muhlfeld and christened the "John B. Jervis."

It seems fittingly appropriate that the officers of the Delaware & Hudson Company should have so signally honored themselves by christening these two examples of modern railway engineering development for two of the most prominent railway engineers of 100 years ago.

Horatio Allen was the chief engineer of the Delaware & Hudson, for which he designed their first locomotive in 1830. John B. Jervis was chief engineer of the Mohawk & Hudson Railroad and the designer of the locomotive, "De Witt Clinton," which went in service on what is now a part of the New York Central Lines in August of 1831. An early record states:

> "Early in August 1831 the Mohawk & Hudson was ready for operation and on the 9th of that month an excursion train was run over the line between Albany and Schenectady. It was drawn by the locomotive 'DeWitt Clinton,' which was built at the West Point Foundry in New York City, from designs furnished by John B. Jervis, chief engineers of the railroad company.
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> "The 'DeWitt Clinton' has four wheels, all drivers four and a half feet in diameter. The wheels have cast iron hubs, spokes turned and polished and wrought iron tires. There are two cylinders 5½ miles by 16 inches and these are set at the side of the firebox at an angle of 30 degrees. The power is transmitted to inside cranked axles on the first pair of wheels. The wheels are connected outside by side rods in the form of double trusses.
>
> "The most conspicuous thing about the engine is the boiler, which is horizontal and has a huge dome which overshadows the rest of the engine. The boiler has 30 copper tubes, 2½ inches in diameter and six feet long, and was fed by pumps operated vertically by a bell crank. The firebox has two doors one above the other. The steam pressure carried is 50 pounds to the square inch. When the boiler is filled with water and the firebox is charged with wood the whole thing weighs four tons. When in good working order the engine hauls five cars on a good level track at a speed of 30 miles per hour."

Some idea of the progress in locomotive development from the pioneer designs of Messrs. Allen and Jervis to the two ultra-modern engines designed by John E. Muhlfeld and named by him for them, may be had from the fact that steam pressures have increased from 50 to 400 lbs., or 700 per cent. The diameter of the cylinders of the "De Witt Clinton" were 5½ in. The "John B. Jervis" has cylinders 41 in. in diameter, the area increase being 4,682 per cent. Weights increased from 5 tons to 273 tons in the case of the new engine under consideration, or 5,360 per cent. With this comparison of extremes we return to our text.

For many years the water tube boiler was looked upon as of doubtful utility in marine and stationary practice, while for locomotive use it was not seriously considered until quite recently. Mr. Muhlfeld has not alone used the water tube boiler successfully for the past two years in the "Horatio Allen," with 350 lbs. steam pressure, but with slight improvements which experience suggested, he finds it most suitable for the "John B. Jervis," with 400 lbs. steam pressure.

In the accessability of the parts, both for repairs and operation, Mr. Muhlfeld's latest design bears evidence of careful thought and study. Problems, which when considered in connection with our conventional standard engine would appear impossible, have been solved in a manner that will prompt many to inquire; how is it possible to locate so many parts in so small a space, and while the "Horatio Allen" would not at first blush be called a "thing of beauty" by a connoisseur, the "John B. Jervis" is more pleasing to the eye throughout.

There are features on which we hope to present additional data at a future date. These are the smoke box and front end arrangement, with particular reference to the nozzle and the back pressure on the high and low pressure pistons, also the type of packing rings and the character of the metals used in the pistons and the kind of oil used, especially in the high pressure cylinder.

The tender of this engine at first glance, attracts no particular attention, but on a closer study it will be noted that it has many admirable features, not only in its contour or stream lines, but in its great capacity. It is well proportioned, without any suggestion of oversize or capacity that would mar the appearance of the completed unit.

Attention is invited to the six-wheeled trucks under the tender as compared to the four-wheel trucks used on the tender of the "Horatio Allen." Here, the rear truck carries a Bethlehem Steel Company's auxiliary locomotive which is equipped with roller bearings and referred to in another column of this issue.

More than 25 years ago, when 150 lbs. steam pressure was common, and 180 lbs. about the average, Mr. Muhlfeld designed an engine for the Canadian Government Railways with a boiler pressure of 250 lbs. per sq. in. which at that time was considered by most railway men, as simply out of the question. In 1904, he brought out the first Mallet Compound in America for the Baltimore & Ohio Railroad, with a steam pressure of 235 lbs. Many looked at it with a suspicious eye and muttered, "it won't do," but many were subsequently built that saved millions of dollars for our railways, and the original is still on the job.

In 1924, 350 lbs. steam pressure was inaugurated with the "Horatio Allen," and the doubting Thomases went into executive sessions, but they adjourned with introduction of the "John B. Jervis," with 400 lbs. pressure.

The 1924 design has made 75,000 miles and has a performance record of 1,000 gross ton miles on less than 55 lbs. of coal.

Mr. Muhlfeld has held with courage to his convictions, and the railway engineering profession has profited from the practical application of his designs to operating conditions.

The "John B. Jervis" marks an epoch in locomotive design in this country, and the results obtained from its service will be watched with unusual interest.

Roller Bearing Equipment for Locomotives and Cars

At various times we have felt the necessity of offering criticism of mechanical officers of railways for the seeming lack of progress in certain features of the design of modern locomotives and cars, while at the same time we were fully aware that they were entitled to the highest kind of endorsement and praise for the general results obtained not alone in the design of the rolling equipment, but in the general operating efficiency of motive power and rolling stock.

In many features of design and practice it has often appeared to a "man up a tree" that some details were partially if not entirely overlooked, whereas, much time and money were devoted to features of far less importance than some which we have in mind.

While roller bearing equipments for railway car journals have been considered and experimented with over a period of 25 years, in view of the fact that railways are slow to adopt anything that represents a radical departure from established practice, it is of interest to note the rapidity with which the anti-friction bearing is coming into use. They have been applied to several dining cars on the Pennsylvania for a few years and more recently to a number of passenger cars on that road. The Chicago, Milwaukee & St. Paul, after exhaustive tests over a period of two years, ordered them installed on Pullman cars and passenger coaches to be used in transcontinental service. One hundred and twenty-seven cars were represented in that order alone. The Chicago & Northwestern made its first purchase of roller bearings in 1923, and ordered that additional cars be so equipped during the three succeeding years when they were experimenting with the apparatus. It has been announced that this road has just placed an order for one hundred and twenty cars to be so equipped. These cars are to be used in suburban service as will the forty which the Chicago, Rock Island & Pacific has also ordered to be roller bearing equipped, and there are others. Elsewhere in this issue will be found a rather interesting description of the application of roller bearings to boosters or auxiliary engines of locomotives. We also understand that they have been applied to the four-wheeled leading truck of one of the large Pacific type locomotives used in hauling one of our famous limited trains.

It is generally conceded that the economic advantages of the roller bearing over the plain bearing are great and that their general adoption, particularly for passenger cars, depended entirely on their reliability in service. This, now, too, seems to have been established when we find railways that have experimented with them over long periods ordering them in substantial quantities.

Under the title of "Some Economic Advantages of the Roller Bearing and Locomotive Booster," in another column, will be found a consideration of these devices which would make it seem that both have established themselves as of such real value in economic train operation, that it is no longer a question as to whether railways can afford to use them, but rather "can they afford to be without them."

Heavier Car Loading Campaign

A determined effort to bring about the heavier loading of freight cars by the shippers, receivers and railroads in the territory covered by the Atlantic States Shippers Advisory Board is to be made during 1927.

Greatly encouraged with the success attending the movement of the record-breaking volume of traffic throughout the year recently closed and confident that business will continue to further expand, thus making greater demands on railroad facilities, the members of the Atlantic States Board have recently made "Heavier Loading of Freight Cars" one of the salient features of this year's program.

As a test period in which to perfect their machinery, they have set aside the month of May, next, to ascertain the loading performance of all cars used in the handling of such commodities as cement, brick, fertilizer, sugar and salt, and with the results of these loading performances before them they are expected to later extend the movement to other commodities.

Under the direction of W. J. L. Banham, of the Otis Elevator Co., of New York, general chairman of the Atlantic States Shippers Advisory Board, and J. W. Roberts, general superintendent of transportation of the Pennsylvania Railroad, chairman of the Railroad Contact Committee, plans have been prepared for a thorough analysis of the loading performance data gathered during May.

Each railroad operating in the Board's territory will submit car loading reports to E. J. Cleave, district manager of the Car Service Division of the American Railway Association, and these are to be placed before the Board's Executive Committee and the Railroad Contact Committee for consideration in joint session, following which they will be passed upon by the full membership of the Board itself.

"Heavier Loading of Freight Cars" involves the question of educating the public in its vast possibilities. It has been agitated before, but there have been obstacles in its path, however, in the way of restrictive limitations in certain states. The movement gained momentum during 1926, nevertheless, when the carriers were called on to handle the greatest volume of business in their history. It was purely through the co-operation of the shippers, particularly those making up the membership of the Atlantic States Advisory Board, covering a territory that is industrially supreme, that the railroads were able to make their excellent showing. In fact, according to a prominent eastern railroad official, the general performance throughout the year 1926, now of record, affords ample basis for the conclusion that one of the factors which contributed to that very satisfactory situation was represented by the proper handling of available freight cars, and that the proper handling included of course utilization of the capacity of the equipment at least reasonably consistent with the known unavoidable limitations.

The Oil-Burning Locomotive

Experiments using oil as a locomotive fuel were made in Pennsylvania shortly after the discovery of the famous rake well in 1859, but the relatively high price of oil, production being limited virtually to the Appalachian region, as compared with less expensive Pennsylvania and West

Virginia coals in the same region, prevented the continuance of its use at that time, states E. B. Swanson, economic analyst, of the Bureau of Mines, Department of Commerce. The first experiments in the United States which resulted in the continued utilization of oil as a locomotive fuel were made by the Central Pacific Railroad (now part of the Southern Pacific system) at its Sacramento, Cal., shops in 1879, when oil brought by boat from the Atlantic Coast was burned in the firebox of an eight-wheel locomotive built to burn wood, but at that time using coal. The Atchison, Topeka and Santa Fe Railway Company began its experiments in 1894 and shortly thereafter converted all of its engines operating west of Winslow, Ariz., to oil burning. Crude oil production and refinery output of fuel oil in California had increased, by that time, to an extent sufficient to meet the local demands for oil as a locomotive and industrial fuel. The problems of burning and storing were met and the foundation laid for the increased use which followed when additional supplies were made available through the discoveries in Kern County in 1899.

The discovery of oil in quantity in Kern County, California; bringing in of the Spindle Top field in Texas and the development of crude oil production in Mexico were three almost simultaneous events which forecast the increased use of oil as a locomotive fuel. The techniacl pioneering had been accomplished and these discoveries resulted in a supply adequate for the extension of its use. Crude oil production in California increased from 2,642,095 barrels in 1899 to 24,382,472 barrels in 1903. By the discovery of the Spindle Top or Beaumont district on January 10, 1901, crude oil production in Texas increased from 836,039 barrels in 1900 to 4,393,658 barrels in 1901 and 18,083,658 barrels in the following year. Discovery of oil, virtually at the same time, in California and Texas furnished an adequate supply at both terminals to the transcontinental railroads operating between Texas and California, simplified the distribution problem and facilitated greatly the introduction of oil as a fuel. While the Mexican discoveries did not increase the supply of crude oil available to the United States at that time, they did lead to the burning of oil on Mexican locomotives in 1901 and, at a later date to the shipment of Mexican topped crude to the United States for use as a locomotive fuel.

Conversion from coal to oil burning was accomplished readily in California as there were no coal deposits commercially available within the state at that time and it was necessary to import coal from British Columbia and Australia. For the railroads of south and west Texas, the long haul from coal fields producing a suitable quality of locomotive fuel; the ample production of Texas oil fields; and the availability of Mexican oil at Gulf ports made the change to oil burning especially attractive.

The Southern Pacific lines in Texas began the use of oil for locomotive fuel shortly after the Spindle Top discovery. After a period of experimentation extending from 1901 to 1905, these lines rapidly changed over all their locomotives from coal to oil, the complete change being effected about 1906. In California, the demand for oil increased steadily during the ten years following the Kern County discoveries and the railroads operating locally in that territory converted all of their locomotives to oil. By 1910, the oil demand and supply were virtually in balance. Hardly had this balance been reached, however, when the Lakeview gusher opened new sources of supply and made possible further extensions in the use of oil as a railroad fuel. Oil was introduced by the railroads having their western terminals on Puget Sound, especially on those divisions which traversed the heavily wooded sections of the Cascade Mountains where the use of oil, it was felt, would reduce the fire hazard.

Some apprehension as to the available supply of fuel oil was felt in 1914 and 1915, when the increasing number of automobiles caused a heavy demand for motor fuel. When it became evident that improving refinery technique would supply motor fuel without affecting seriously the supply of fuel oil, consumption again increased, stimulated at the same time by the possibility of importing Mexican fuel oil. The Florida East Coast Railway inaugurated the use of oil as a locomotive fuel on its lines in 1916, using Mexican oil. The Missouri, Kansas and Texas Railway placed its first oil burning locomotive in service in 1919, later in the year adopting oil as fuel entirely on its Texas lines, burning both Mexican and domestic oils. The flush production of 1923 in Southern California resulted in an increased use of oil by railroads of the Pacific Northwest, whose fuel oil supply was reduced during the scarcity period of 1920 and 1921 on the Pacific Coast.

During the year of 1925, the largest railway purchasers of fuel oil were the Southern Pacific Company and the Atchison, Topeka & Santa Fe Railway. Both of these companies used more than 5,000,000 barrels and there were six other railways that used between 2,000,000 and 5,000,000 barrels. No less than 147 railways used fuel oil to some degree in their operations, but its use in such large quantities as those cited was limited to few.

Until recently, a considerable quantity of Mexican oil was imported for use as a locomotive fuel, but the railroads, with some important exceptions, are at present depending on the domestic supply for the bulk of their needs. Considerable quantities of California, Texas, Louisiana and Arkansas crude oil were burned as fuel in the past, without refining, but the present supply is, in the main, a refinery product, the fuel oil being that portion remaining after the crude oil has been refined, either by straight distillation or by cracking.

Pennsylvania's New Coaling Station at Conemaugh, Pa.

To facilitate the movement of freight on its main line, the Pennsylvania Railroad is bringing to completion at Conemaugh, Pa., extensive improvements, the construction of which necessitates the unusual task of moving bodily a stretch of the Conemaugh River from its natural bed to an entirely new channel.

The new facilities consist of a mechanically operated, large capacity locomotive coaling station, with extensive trackage to permit the engines of 100-car freight trains to take coal and have their fires cleaned while clear of the main tracks. To provide trackage of the required length, it was necessary to extend the east end of Conemaugh Yard. Owing to the abrupt rise of the mountains on the north side of the right-of-way, the only feasible plan was to fill in the old bed of the river from the north bank and cut a new channel to the south.

The coaling station proper is being constructed almost in the center of what was formerly the old river bed. It will be of 250 tons capacity and the coaling bridge, which will span all the tracks, will be capable of supplying fuel to nine locomotives at a time.

Approximately 80 engines, handling heavy freight trains, take water at Conemaugh Yard daily, and have ash pans and fires cleaned. The total movement through the year, which is one of the most important on the Pennsylvania Railroad's main line, often approaches 7,000 freight cars in twenty-four hours. The new facilities are required for the efficient, expeditious and economical handling of this vast and growing traffic. The work is proceeding night and day and is expected to be completed in February.

Development and Testing of Railway Draft Gears

A Paper Read Before the Railroad Section of the American Society of Mechanical Engineers

By A. F. Steubing

The movement of freight traffic on the railroads of this country is notable for the large loads handled in individual cars and in trains. The ordinary 50-ton car carries an actual load of about 125,000 lb., and has a total loaded weight of 169,000 lb. The largest freight cars in regular service are the Virginian Railway's special gondolas with a capacity of 240,000 lb., and a total weight of 315,000 lb. Train loadings vary greatly but 100-car trains of 6,000 to 8,000 tons are not unusual on lines with moderate grades, and on the Virginian maximum train loads of 16,000 tons have been handled.

In my paper this evening, I shall discuss some of the problems encountered in dealing with the forces set up by these large masses during impact, as in hump yard switching, and in starting and stopping heavy trains. Most of this discussion will be devoted to the draft gear which cushions the forces between cars. This is so intimately associated with the coupler and underframe, that it seems necessary, by way of introduction, to describe briefly the standard construction of the present day and explain the successive steps leading to its adoption.

The first means of connecting cars was by chains and hooks. This was displaced by a drawbar having an open end through which a pin passed so that cars could be connected by inserting the pins through links fitting in the opening in the drawbar. Springs were interposed between the drawbar and the car underframe to ease the shocks developed in impact and in train service. About 1880, the Janney coupler having a knuckle pivoted on a vertical pin was introduced. This type has now become standard on American railroads.

George Westinghouse developed and applied the first friction draft gear. The first patent was granted to Mr. Westinghouse in 1888, and friction draft gear came into use on a limited scale before 1900. Since that time service requirements have constantly grown more severe and draft gear design has become one of the major problems pertaining to freight cars. Many engineers have struggled with the problem of developing a design which would meet all requirements. The majority of these efforts have resulted only in an addition to the records of the patent office. There are now more than 1,200 patents on friction draft gears, but there are only about 12 different types in general use.

At the present time, there is no standard specification for draft gears and there is little agreement as to the characteristics required. The Mechanical Division of the American Railway Association, in its Fundamentals of Car Design, specifies a minimum capacity of 150,000 lb., and a travel of 2¾ in. As a rule, a minimum impact capacity of about 12,000 ft. lb. is required by the railroads. Authorities are not agreed as to the amount of travel which is most desirable. Some are in favor of approximately 2 in. travel, while others advocate making it as great as 4 in. The long travel has the advantage that it permits development of greater energy capacity with a given maximum force. Advocates of short travel contend that the necessary capacity can be obtained in 2 in., without exceeding the maximum allowable force and that long travel is likely to permit too much movement in train service and thus set up destructive shocks.

Smoothness and uniformity of action are very desirable. Some gears are greatly affected by the deposit of rust and dirt on the friction surfaces and some are subject to a considerable decrease in capacity, due to moisture in the atmosphere. Some draft gears are readily closed by the repeated application and release of a force far below the capacity developed when the gear is closed in single movement. This so called creeping is an undesirable characteristic, as the same action might take place due to the variation in the tractive force of the locomotive.

Sturdiness is a very vital characteristic because the draft gear is subjected to enormous forces in oversolid impacts. The A.R.A. recommendation is that the draft gear shall have a minimum strength equivalent to 20 sq. in. of Grade A cast steel. This is intermediate between the coupler which has a cross section of 15 sq. in., and the center sill with an area of 28 to 30 sq. in. It seems questionable whether anything is gained by making the strength of the draft gear greatly in excess of the strength of the coupler.

It is essential that the rate of wear in a draft gear be relatively low, as it receives attention at very infrequent intervals. In some designs the pressure is made comparatively low, by increasing the friction area with the object of preventing abrasion. Unit pressures in different designs vary from 200 lb. to 5,000 lb. per sq. in. on the friction surfaces. The National draft gear illustrated has a friction area of 53 sq. in., whereas one design of the Hall gear has 2,000 sq. in., or approximately 38 times as much. The Hall gear uses rolled steel plates for friction members, whereas the National gear is made of special electric furnace cast steel, hardened to reduce the rate of wear. Another combination which is used quite extensively for the friction members is hardened high carbon steel working against malleable iron.

The simplest test and the one which was most used when draft gears were first developed, was the closure of the gear in a static compression testing machine. This method was satisfactory and reliable for spring draft gears, but was found practically worthless for many designs of friction gears. For example, a comparison of the resistance developed by two draft gears of the same type under varying speeds of closure in static tests and the resistance of the same gears when closed by car impact. It was found that the static tests, especially at the speed of 1/8 in. per min., show great variations, whereas the capacity developed when closed on the cars correspond fairly well for the two gears.

The realization that characteristics developed by draft gears when closed by impact are entirely different from those shown in static tests led to the development of methods for testing gears by impact. The method ordinarily used is to allow a weight of 9,000 lb. to fall on the draft gear from a predetermined height. As the weight is checked by the resistance of the gear, the amount of closure is measured. The height of drop is gradually increased until the gear is driven solid. To test the sturdiness of the gear, repeated drops are made from increasing heights beyond the closing point.

The test which gives the closest approach to the conditions under which draft gears operate is the car impact test. In this test the gears are applied to cars and a moving car is allowed to strike a stationary car, complete records of the movement of both cars being obtained on recording instruments from the instant of impact until the cars part.

Collisions between cars equipped with spring draft gears approximate the condition of elastic impact. On the other hand, cars equipped with friction draft gears act more nearly in accordance with the laws of inelastic impact.

Applying this principle to specific cases brings out some interesting features regarding the theoretical action of cars in impact. Assume first that a moving car strikes a standing car, both being of the same mass. If the cars are equipped with spring draft gear and the impact is not in excess of its capacity, the striking car will be slowed down and the struck car will be accelerated up to the instant of maximum compression when both will be moving at uniform velocity equal to one-half the initial speed of the striking car. The draft gears will continue to exert force on the cars until the gears are again fully open. The deceleration of the striking car and acceleration of the struck car will continue until they part, the striking car coming to rest and the struck car moving on with a velocity equal to the initial speed of the striking car. If the striking car is one-half as heavy as the car which is struck, the striking car will move in the reverse direction with ⅓ its original speed and the struck car will move in the direction of the impact at ⅔ the initial speed of the striking car. If the striking car is twice as heavy as the car that is struck, the striking car will continue in motion at ⅓ its original speed and the struck car will move on in the same direction at 4/3 the original speed of the striking car. If the mass of the striking car is many times as great as that of the struck car, the velocity of the latter after impact will be nearly twice the original speed of the striking car.

In the case of inelastic impact, as between cars equipped with friction draft gears, the action up to the point of maximum compression is the same, but there is no restitution of the energy expended in compressing the draft gears and the cars move on at the common velocity of the two bodies at the time of maximum compression. In elastic impact the final decrease in the velocity of the striking body and the final increase in the velocity of the struck body are twice as great as in inelastic impact.

In actual service there is always some absorption and some restitution of energy, so that neither spring nor friction draft gears act strictly in accordance with the equations given.

It is interesting to note that if the resistance of the draft gear is proportional to the closure, the time of closure is the same for light or heavy impacts within the capacity of the gear.

The energy and force relations outlined in the preceding paragraphs are extremely important in designing draft gear. Referring again to the typical case of impact between two cars of equal weight, it is evident that the draft gear in each car should be of such construction that the work required to close it at the maximum permissible velocity of impact would be equal to ¼ the kinetic energy in the striking car at the instant of impact. This is modified somewhat by the frictional resistance in the movement of the car and the work done on the car structure.

Much valuable information concerning the actual performance of draft gears in impact has been obtained on the testing plant built in 1917, by The T. H. Symington Company, at Rochester, N. Y. This test plant consists of a straight track with two full-size cars which can be caused to collide at any desired velocity, means being provided to record the results of the impact. The first portion of the track is inclined in order to impart velocity to one of the cars. At the foot of the incline is a section of level track where the impact takes place. The cars can be equipped with any type of draft gear and are fitted with dummy couplers so that they are free to move after impact, under the influences of the forces set up during the draft gear cycle.

During the test run, records can be taken of the velocities of the striking car and the struck car, of the travel of the cars along the track, and of draft gear travel and action. From these records the action of both the gears and the cars can be studied.

The car impact test seems the most logical means of rating draft gears on the basis of laboratory performance In spite of this fact, it has not come into very general use. Both railroads and draft gear manufacturers prefer a method of testing that does not require such expensive equipment or complicated records. For that reason the drop test is more extensively used than the car impact test.

The velocity at impact under a 9,000 lb. falling weight is considerably greater than the velocity of a loaded car which in impact would do the same amount of work on the draft gear up to the closing point. It has been suggested that because of the decrease in the coefficient of friction resulting from an increase in speed movement, friction draft gears do not give the same performance in the drop test that they do in actual service. It is interesting to analyze the various tests conducted during the U.S. R.A. investigation of draft gears with a view to determining how the speed of closure affects the work done. In the U.S.R.A. tests, 18 different designs of draft gear were tested under the 9,000 lb. drop, and in car impact in single gear runs with a solid buffer in Car A and a draft gear in Car B, and in double gear runs with two draft gears of the same type in Cars A and B. If the variations in performance are due to changes in the coefficient of friction resulting from increases or decreases in speed, it is to be expected that the work done in the drop, where the velocity was greatest, would be the least, with double gear run next, and the single gear run developing the greatest capacity. A comparison of the work done in these tests is shown in Table 1. There is little evidence to indicate that speed is an important factor in draft gear performance within the limits covered by these tests. There is little agreement between the ratio of work done in the double gear test run to work done by the same type of gear in the drop test, the ratio ranging from 71 per cent to 139 per cent, the average being 106 per cent. The average ratio of 106 per cent is in agreement with the theory that the work done increases as the speed decreases. Comparing the ratio of work done in the single gear closing speed runs to the work done in the drop test, shows a wider variation, the limits being 79 per cent to 198 per cent, with an average of 121 per cent. The ratio of work done in the single gear run to work done in the double gear run varies from 84 per cent to 169 per cent, the average being 114 per cent.

Aside from variations in the coefficient of friction, the capacity of draft gears in the drop and car impact tests might be affected due to atmospheric conditions or the condition of the friction surfaces, by slight inaccuracies of manufacture, causing variations in capacity of different gears of the same type, by the effect of alternate closing in the double gear runs and by variations in operation, due to the position of the gear, which is placed vertically in the drop test and horizontally in car impact tests. It seems impossible to determine separately the effect of each of these factors. The performance of draft gear is influenced by so many variables that no two tests could be depended on to give identical results.

The American Railway Association has authorized an appropriation for the purpose of building, installing and housing a drop test machine for testing draft gears to determine their capacity, recoil, smoothness of action, sturdiness and endurance, and from the information obtained prepare suitable specifications under which the railroads may purchase draft gears that are known to meet the prescribed standards of efficiency. It will also be used to obtain information that will be of assistance in developing draft gears generally.

A novel feature of the machine is that it will be provided with two falling weights or tups. The larger one will weigh 27,000 lb., and is believed to be heavier than any heretofore used for the purpose, while the smaller one will weigh 9,000 lb., which is the weight most frequently used in similar test machines used in the past. The design is such that the weights may be readily removed or applied without dismantling the vertical columns.

The machine will be driven electrically, the control equipment being so designed that operation may be manually or automatically controlled and it will be provided with a chronograph for recording the action of the draft gear or gears being tested throughout the cycle of compression and release.

The drop test machine is nearing completion and will be installed at an early date at Purdue University, Lafayette, Indiana.

Name of Gear	Work Done in Drop Test	Work Done Single Gear, Closing Speed Runs	Work Done Single Gear Run, % of Work Done in Drop Test	Work Done Double Gear, Closing Speed Runs	Work Done Double Gear Run, % of Work Done in Drop Test	Work Done in Single Gear Run, % of Work Done in Double Gear Run
National H-1	23,400	33,633	144	27,184	116	124
Sessions K	14,100	28,017	198	19,366	137	145
Miner A-18-S	14,925	20,117	135	18,716	125	108
Westinghouse N-A-1	18,750	16,167	86	19,167	102	84
National M-1	14,400	21,300	148	20,000	139	106
Sessions Jumbo	21,075	21,317	101	19,025	90	112
National M-4	16,125	25,000	155	18,466	114	135
Cardwell G-18-A	14,800	16,500	111	17,116	115	96
Cardwell G-25-A	14,175	18,233	129	17,916	126	102
Westinghouse D-3	14,850	15,617	105	14,666	99	107
Gould 175	13,575	14,900	110	13,767	101	108
Murray H-25	12,750	14,800	116	13,900	109	106
Christy	14,700	21,817	148	12,933	88	169
Miner A-2-S	9,900	10,500	106	10,025	101	104
Waugh Plate	10,425	8,283	79	9,100	87	90
Bradford K	8,100	7,833	97	6,833	84	115
Harvey 8 x 8 Springs	7,025	6,650	95	4,991	71	131
Two 8 x 8 Class G Springs	4,350	......	...	4,116	95	...

Discussion by Wilson E. Symons

The subject is so broad, complicated, and I might say so generally misunderstood, that one seems almost at a loss as to the most inviting angle of attack, or method of procedure in offering comment, criticism, or suggested remedial measures.

First of all, and prior to touching on the engineering features involved, it seems to me as quite in order to favorably comment on the propriety of holding this meeting in this particular room, where we have before us as an inspiration, a framed portrait at one corner of the room, and on a pedestal in the other corner, a portrait bust of the late George Westinghouse, the original inventor of the friction gear and a past President of the A. S. M. E. Under the circumstances, it seems to me as not inappropriate to offer a few remarks of a historical character, if for no other reason than we may make fitting acknowledgment of the achievements of a distinguished citizen, a great engineer and the father of the "friction gear."

Following the successful introduction of air brakes on railway trains in the U. S. by Mr. George Westinghouse, he invaded England, where he made much progress against what appeared to be greater opposition than in this country.

An exhibition or demonstration of the practicability of the Westinghouse brake was given on one of the railways outside the City of London, known as the Galton-Westinghouse Tests, to which many notable men in the fields of finance and railway operation were in attendance.

On the return trip to London from this trial test, a very unfortunate accident happened to the train bearing this distinguished party home. The engineer, or engine driver, in attempting to give an extra, or final, exhibition of his ability to make a quick effective stop at the terminal station, overdid the matter, with the result that the train, after coming to a state of rest, was suddenly snapped apart on release of the brakes, through the destructive action of stored up energy in the buffing springs between the cars. This sudden kicking of the detached portion of the train in the reverse direction, threw many of the guest passengers to the floor of the cars, obviously materially marring the pleasure of their otherwise pleasant trip, and incidentally somewhat disturbing their previously-formed opinion of the new air brake.

Mr. Westinghouse, much chagrined at this unfortunate incident immediately saw the necessity for a shock absorbing device that would so function as to preclude the possibility of such accidents and at once worked out the details of a friction gear.

During the intervening years, numerous imitations of, as improvements on, the friction gear have been brought out, in most of these however the fundamental features of a device to function as its original designer intended it should, and for which there is a crying need today, have been overlooked or ignored, the trend in many designs being only for increased capacity, without any definite feature, that will positively function under all operating conditions to prevent the dangerous kick from recoil action of compression springs which is the very thing, and the most important function for which the friction gear was invented, designed and intended to do.

Certainly we have not only strayed far from the trail blazed by the pioneer, but in my opinion the majority of friction gears now in use do *not* function under all operating conditions, and their failure is in the most important feature for which the device was originally designed, and is now used on our greatly increased capacity freight equipment.

I venture the assertion, although I have no definite figures at hand, that if the draft gear on our freight cars was exposed to view for ocular inspection of car inspectors as to physical condition and actual functioning in closing and release action, as clearly as the wheels, brake beams, brake shoes, axles, oil boxes and contained parts, etc., and were marked out with B.O. chalk marks for repair track, that at least 30 per cent of revenue freight cars would at once go out of service at first inspection point (a voice: "you are too low, it would be more than 30 per cent).

This condition to my mind is the result of two things, viz.:

(a) A departure from the underlying, or fundamental principles involved.

(b) Highly developed commercialism, and until these features are corrected, the friction gear problems will, in all probability, remain in a more or less chaotic state.

Some gears of high resisting capacity, as shown by laboratory drop tests, deserve to be rated high as destructive agents to car and contents and correspondingly low in the essential elements of an efficient shock absorbing device under all actual operating conditions. This condition, I believe, applies to most all friction gears in which the friction capacity predominates over springs in total capacity and where friction elements function through action of angle or wedge blocks, held in contact through resistance of compression springs.

This design, I think, is wrong in theory, and defective in practice. The situation at present is one in which we may look for most important changes in the not far distant future.

When the automatic coupler problem was in a state of development some 25 years ago, somewhat similar to that of the draft gear problem at the present time, there had been patented between 4,000 and 5,000 car couplers and there was in actual use about 45 to 47 different kinds for which railways had to carry in stock repairs or replacement parts.

Most of the 5,000 inventors of couplers and all of the 45 to 47 manufacturers were not only willing to admit, but were quite insistent, as to theirs being the only device that should be allowed on equipment, while many of them were the wildest kind of freak contraptions with more elements of danger than the old link and pin coupler.

In the draft gear field today, we have a great variety and assortment of friction gears, there being about 48 different types and priced devices on the market made by about 12 or 13 different manufacturing concerns. While Mr. Stuebing has just told us that something more than 1,200 patents have been taken out, from the foregoing it must be clear that before much can be said about standardization, that there must first be determined in language void of ambiguity, a standard based on capacity and efficiency in actual service accomplishing the thing that it is sought to have effectively done in car and train movement, than by an orderly process of installation and elimination, get down in a reasonably short period of time to the best suitable device for the service requirements.

I hold no brief for any interest, but it is my belief, and has been for many years, that among the most important features of friction gear design should be the following:

Gears should be a self-contained unit of a size to completely fill the entire space of A.R.A. gear pocket, by which plan the manufacturer will be held responsible for every piece and part of the device as applied.

Gears should be high in compression spring capacity, and with sufficient friction capacity, entirely independent of compression springs, to not only add to total, or combined resisting capacity of the completed unit, but absolutely positive as to functioning in release movement and thus insure absolute protection against the adverse or damaging results from kick or recoil of compression springs.

Gear should be sturdy and rugged and develop both friction and spring resistance with slightest movement and at all points of travel, and function under all operating conditions.

There is now a wonderful field open for development and during the next five years great strides will be made, with the probability that even present plans of procedure will undergo many changes, and that finally the gear question will not be unlike the coupler problem in its solution.

Motor Generator Locomotives for the Great Northern Railway

By C. E. Baston, Railway Equipment, Engineering Department, Westinghouse Electric & Manufacturing Company

Two motor-generator electric locomotives for the Great Northern Railway have been completed and shipped to their destination from the East Pittsburgh Works of the Westinghouse Electric & Manufacturing Company. They will be placed in operation between Skykomish and Cascade in the State of Washington, a distance of 26 miles. This section of the line is on the western slope of the Cascade Mountains and has many curves, and a grade against eastbound traffic averaging two per cent, the maximum being 2.2 per cent. The line passes through numerous tunnels the longest of which is the Cascade Tunnel, 2¾ miles long, located near the summit of the mountains.

When the Great Northern Railway decided to extend the original electrification the management foresaw great possibilities in the motor-generator type of motive power by which the advantages of alternating current high-voltage transmission and trolley and superior features of direct current traction motors could be secured in the same unit. The use of the motor-generator locomotive minimizes the copper and power losses, permits unattended transformer stations, light overhead trolley construction and a wide range of flexibility in the control of the locomotives.

These locomotives operate from an 11,000-volt, 25 cycle single phase trolley. The alternating current is transformed and converted into direct current for the traction motors by the assistance of the transformer and motor-generator set on the locomotive, thus eliminating the necessity for converter sub-stations located along the right-of-way.

The locomotives were designed and constructed jointly by the Baldwin Locomotive Works which built the mechanical parts and the Westinghouse Electric & Manufacturing Company, which supplied and installed the electrical apparatus. Each locomotive consists of two cabs or motive power units operating in multiple and connected by means of a draw bar. The weight of a complete locomotive is 357.5 tons of which 274.8 tons are on the drivers. Each unit of a locomotive is complete in itself and can be operated independently of the other.

The principal dimensions and specifications are as follows:

Weight on each driving axle	68,700 lb.
Weight on each idle axle	41,350 lb.
Length between Coupler Knuckles	94 ft. 4 in.
Total Wheel Base	78 ft. 6 in.
Rigid Wheel Base	16 ft. 9 in.
Height over Pantegraph Locked Down	15 ft. 10 in.
Height over Cab	14 ft. 2 in.
Width over Cab Sheets	10 ft. 5 in.
Width over Grab Handles	11 ft. 0 in.

Ratings (With Forced Ventilation)

	Hour	Continuous
Horsepower	4330	3660
Tractive Effort	112500	88500
Miles per Hour	14.4	15.5
Amperes per Motor	750	625
Maximum Tractive Effort	(50.4% adhesion)	277,000 lb.
Maximum Safe Speed		37.5 m.p.h.

The wheel arrangement is the familiar 1-D-1 classification. Each unit has a box-type cab which is mounted solidly on the locomotive frame and has an operating compartment at one end separated from the equipment compartment by a bulkhead with doors opening into each side aisle. Provision has been made at the opposite end of the cab for a second control stand should it be found desirable to operate a unit regularly as a single cab. To add rigidity and distribute the weight, a central integral casting is carried on the locomotive frame on which are mounted the motor-generator set, the transformer, the air compressor and other heavy equipment.

Current is collected from the overhead wire by two pantagraphs on each unit, only one of which is necessary, however, the other being held as a spare. All four pantagraphs are connected in parallel by a high tension bus line. Power is conducted from the bus line through an oil-insulated, circuit breaker to an airblast transformer where it is transformed to a lower voltage and delivered to the synchronous motor of the motor-generator set. The motor generator set is a two-bearing machine composed of a synchronous motor driving a 1500 kw., 600-volt direct-current generator. A 125-volt, 75 kw. direct-current machine overhung on the synchronous motor bracket is used to furnish excitation for the various machines and power for some of the auxiliaries. The generator bracket carries another direct-current generator used for exciting the fields of the traction motors when regenerating and when high speed is desired with heavy loads.

Each main axle is driven by a single axle-hung direct current series type traction motor through a solid pinion on each end of the armature shaft meshing with a flexible gear mounted on the hub of each driving wheel. The four traction motors of each unit are connected in parallel, but any one or all can be entirely isolated when necessary.

Two blowers used for ventilating the traction motors and one for ventilating the transformer are driven by single phase induction motors. To start these motors, the main synchronous motor is equipped with a secondary winding which is connected with the main transformer to give three phase power. When the synchronous motor is under load this three phase connection is broken and the motor operates as a single phase machine.

Compressed air for the control and air brake systems is supplied by a two-stage compressor having a capacity of 150 cu. ft. of air per minute and driven by a direct-current series motor fed from the main exciter.

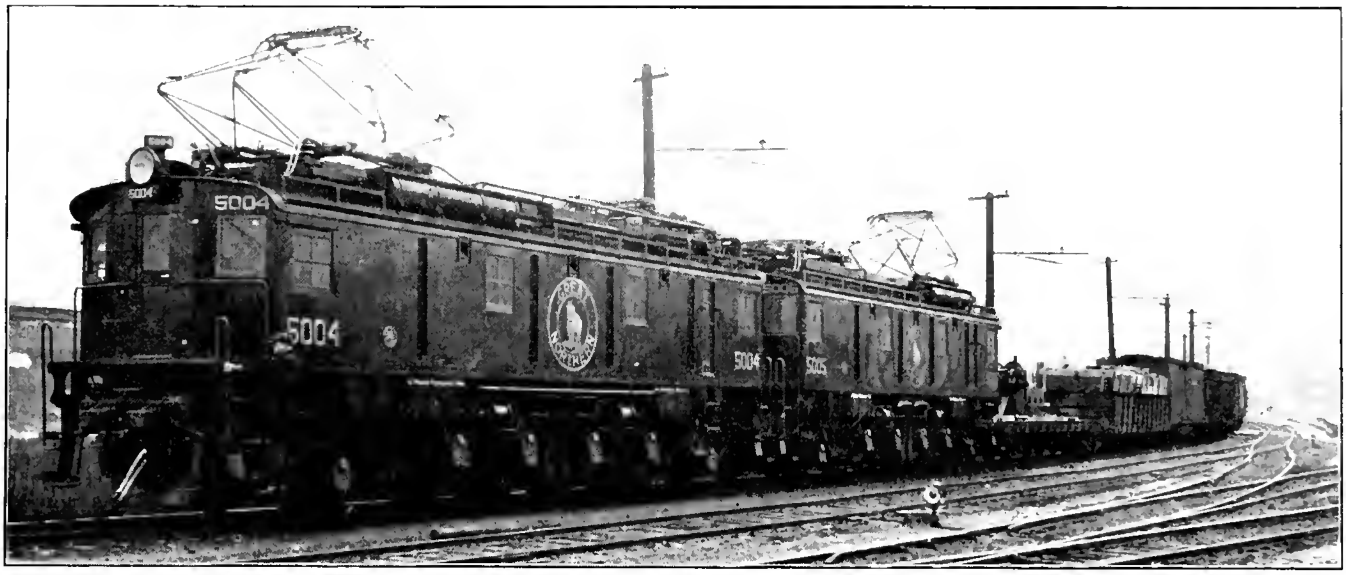
A 125-volt, 238-ampere-hour lead type storage battery supplies power for starting the main motor-generator set and, during interruptions of the trolley circuit, for running the compressor and for control and lights.

The control is the Westinghouse type HBFR electro-pneumatic type. Acceleration is entirely by field control of the main generator and traction motors. Thirty positions of the controllers for both the main generator and the traction motor fields are provided. The transition from series to separate excitation of the traction motors or vice versa can be made at will without any change in tractive effort.

These locomotives are capable of hauling a 1000-ton trailing load between Skykomish and Tye at a speed of 19.8 m.p.h. and using a second locomotive as a pusher they can haul a 2800-ton trailing load at 15.4 m.p.h. over this same section.

In case of a change in trolley voltage or grade which would overload the locomotive, the load is automatically reduced and an indication given to the engineman. Stability of the synchronous motor is insured by automatically increasing the excitation when there is a possibility of the motor pulling out of synchronism. Momentary interruptions of power are obviated by always operating with two pantagraphs raised, but should they occur, a special relay is provided which removes the load and reconnects the main motor to the starting connections until power is restored when it is automatically synchronized and the load re-applied. Balancing of the load on the two units is taken care of by bus line connections between the main exciters which equalizes the voltages being applied to the main generator fields. The traction motor circuits are so adjusted that they divide the load equally with both the series and separately excited connections. The traction motors are grounded only through a ground detector which indicates at all times the condition of the circuits and in case of trouble indicates which side of the circuit is grounded. Before a failure can result a second ground must occur before the first ground indicated has been removed. Should a ground be indicated by the ground detector, further trouble may be prevented by opening the motor cutout switch of the motor involved which will isolate the motor entirely. The main generator is protected against a short circuit in the motor by a fuse in each motor circuit. Meters are provided to enable the engineman to determine the operating conditions of both cabs.

The ability of this type of locomotive to deliver its full



Two Unit Motor Generator Locomotive of the Great Northern Railway rated horsepower over a wide range of speed and to employ regeneration almost to standstill makes it adaptable to a wide variety of requirements.

Grease Lubrication on Locomotive Driving Journals and Crank Pins

By J. Duiguid, Engineer of Tests, Galena Signal Oil Co.

PART II

Grease was not applied to driving journals and crank pins with the idea of reducing their normal frictional resistances, but rather to meet the following conditions:

1. In the case of driving boxes it was impossible to keep an oil waste pad in proper lubricating condition.
2. That the heavy reciprocating thrusts broke through the oil films and the result was metal contact.
3. The saving in labor applying driving box lubricants.

In the case of crank pins it was difficult to retain oil in the cups, and the reciprocating thrusts broke through the oil films.

The mechanical appliances for the application of grease to driving journal are fairly efficient, but the method of feeding grease to crank pins is crude, and not efficient and the only feed of grease from the cups to the pins (after the initial manual application) is that due to expansion by temperature; and the temperature must increase pro ratio to the grease density to feed any grease to the pins. This means that after the locomotive has run a stated number of miles that a very high temperature is developed before any grease is fed by expansion.

If some mechanism could be devised that would feed a uniform volume of grease to the pins irrespective of their temperatures it would greatly improve such lubrication.

With grease lubrication on driving boxes there is a prevalent idea that the bearings must reach high temperatures before the grease "starts to lubricate," and they judge these temperatures by feeling the hubs or boxes with the naked hand, and these tmperatures judged in this way appear to be increasing for perhaps the entire run, whereas the rubbing surface of the journals and bearings and grease reaches its maximum temperature in a few minutes after the locomotive is started, but it takes some time for the outer surface of the mass to reach high temperatures, or in other words, the temperature of the rubbing surfaces remain uniform while the temperatures of the outer surface will gradually increase.

The temperature of the mass is somewhat proportional to the atmospheric temperatures, also by the period of time that the engine has been on the run, and also by its velocity through the air, while the rubbing surface temperatures are not greatly affected by these conditions.

To meet the emergencies of service, driving journal grease must stand high temperatures and must therefore be of low heat conductivity and therefore the frictional resistances and temperatures of such a lubricant is high and it is then necessary to provide ample radiation facilities to carry off the excess temperatures.

It is apparent that on many modern locomotives the radiating capacity of the driving boxes is inefficient due to the flow of air over the boxes and over the center part of the axles being restricted on account of the large cylinder saddles, the heavy frame fillers, large and cumberous frame cross ties, large brake beams and brake rods and levers, all of these tending to make a pent up condition of the boxes and corresponding low radiating capacity. In other words, the amount of heat units produced by the bearings have been increased due to the increased rubbing surface while their radiating capacity has been reduced due to their pent up location.

It does seem probable and necessary that some artificial method of radiation is now necessary on the driving boxes of modern locomotives.

Grease lubrication on driving journals produces a normal temperature of about 240 degrees to that of about 180 with oil and the frictional resistances are about pro ratio to these temperatures.

Power Losses Due to Frictional Resistance

The actual load caused by the frictional resistance of the valves and cylinders is not great, but the losses in power and steam due to the wear of these parts is a very important consideration; such wear causes loss of steam to the exhaust and faulty steam distribution, and when it is remembered that even with 100 per cent perfect mechanical conditions a small percentage of the heat of the coal fired is available as power at the piston rod, then any undue or abnormal wear of these parts causes serious loss.

Probably the principal reason why the lubrication efficiency of oil is not given more general attention is because a great proportion of the losses incurred through faulty lubrication are hidden. As long as an oil is not giving any unusual or flagrant trouble, it is often assumed that it is efficient, while as a matter of fact, it may be causing a heavy powerload factor.

Even when the friction load is known it is often misunderstood, or rather misinterpreted, as to its relationship to other factors. As an illustration of this, at the time of the Federal Administration of Railroads the problem of fuel conservation was given close study and attention. I was then attached—in a minor capacity—to the New England States Fuel Conservation Committee. I had occasion to take exception to an item on "Friction of Locomotives," contained in a pamphlet that the committee had copied from a report issued by the Engineering Department of the University of Illinois. This item was to the effect that the friction of the locomotive consumed 1 per cent of the total coal fired. In a sense the statement is approximately correct, yet when taken at face value, as it was by many railway mechanical men, the loss through friction seems insignificant. But when it is remembered that friction's toll is taken after the power is developed at the piston rod and that only 7 per cent of he total coal fired becomes available as power at this point, the loss through friction is as 1 to 7, or about 14 per cent of the generated horsepower.

Therefore, with the proper ratio of friction to developed power established, it may easily be seen that each reduction of one-fourth in this seemingly unimportant 1 per cent becomes equivalent to an increase of nearly 4 per cent in drawbar efficiency. It is always well to remember that when frictional loads are given in percentage of fuel consumed, the ratio of the friction to the power developed at the piston rod or at the motor must be known, also the percentage of the heat units in the coal developed as power at these points, before the true meaning of friction can be estimated in this way.

Reclamation of Used Packing and Oil

A considerable number of oil users assume that old oil or oil that has been in use is unfit for further service; they seem to think that it becomes "worn out," or depreciated in lubricating value. It seems scarcely necessary to try to refute this idea, as it has been repeatedly proven to be erroneous. Tests made at the Engineering Department of Cornell University showed conclusively that lubrication oils (that were not built up) did not "wear out" in service, and while the oils gained in viscosity and gravity—due no doubt to the more volatile parts being dissipated by bearing heat—they gave a lower coefficient of friction at low pressures and but a slightly higher one at high bearing pressures.

From the time new packing is applied, until it is reapplied as reclaimed packing, there is a loss of approximately 40 per cent, of which amount about one-half has been consumed in service and the other half discarded as worthless when reclaiming. This loss is made up by the addition of new packing mixed with the old in this proportion. The cost of reclaiming is about 0.62 cent per lb., depending upon the locality. The relative cost of 100 lb. of new prepared packing as compared with the cost of the same amount composed of 40 per cent new and 60 per cent reclaimed is approximately (with cost of new oil 32 cents per gal, and of waste, 14 cents per lb.)

100 lb. *New Packing*		*40 per cent New—60 p.c. Old*	
Oil, 80 lb.	$3.20	Oil and waste reclamation	$0.45
Waste, 20 lb.	2.80	32 lb. new oil	1.28
	——	8 lb. Waste	1.12
Total	6.00		
	2.85		——
	——	Total	$2.85
Saving	$3.15		

On railroads and street cars viscosity of the reclaimed oil should be inspected, especially in the cold seasons, because if the oil has been in service for a considerable time it is liable to increase to a very high viscosity at temperatures below 75 deg. and when found so, should be cut back with a lighter oil such as winter car oil.

The filtration of used oil is a subject that seems to be of more than ordinary interest and one that oil men are constantly being asked about. While there are many methods of filtering, I believe the following is efficient and will prove satisfactory.

The oil is poured through a screen and then passes through a pipe to a point near the bottom of the precipitating filter where it is heated and the water contained precipitated: the oil then flows to the top of a receiving tank in a zigzag course over horizontal pans which permit the precipitation of the fine particles of foreign matter that it may contain; it is then passed to the cloth filters.

Another type of precipitating filter in general use is one by which the oil travels vertically up and down over partitions in the filter. This method is not to be recommended because it involves the necessity of the dirt contained being precipitated through a high column of oil, whereas in the first-mentioned filter the oil flows in a comparatively thin sheet and the precipitation of dirt is more easily and more thoroughly accomplished.

Some small users of oil filter it through a waste mass instead of the cloth filter. This is a very poor method as there is a great liability of small unseen particles of the waste getting into the oil, and these are very conductive to heated bearings as this material carbonizes on the journal and is often the source of heated bearings on railroad cars.

Other oil users attempt to filter by what is generally known as the "wet" system, which consists of passing the oil through water. The method is practically useless as the oil will pass through the water in drops and inside these drops will still be carried the fine particles of dirt that filtering is supposed to remove.

Many manufacturers are now making centrifugal machines for the cleaning of waste, and centrifugal purifiers for the cleaning of oil. They also manufacture small stills in connection with oil purifiers for the reclaiming of crank case oils from internal-combustion engines and all these machines reclaim oil to practically as good as new oil.

Cost of Lubrication

With the possible exception of those applying to railroad equipment, there are few available or reliable data on the actual cost of lubrication per unit of service rendered. In manufacturing plants there is no common basis that would enable one to make calculations that would be acceptable as reasonable accurate approximations. In plants such as textile mills the greater percentage of power is consumed in overcoming friction and maintaining the acceleration of numerous high-speed parts, while in plants on the order of heavy machine works where the greater percentage of power is applied directly for useful work, the friction load of the bearings is low, and ascertaining the cost of lubrication is an entirely different proposition.

Lubrication service is so widely divergent that it would be impossible to establish a standard of efficiency that would be generally applicable. But invariably it will be found that the use of lubricants that can demonstrate the highest service efficiency will, regardless of their necessarily higher price, return the lowest actual unit costs for the work required.

To properly estimate the cost of lubrication, the following data would have to be available:

Quantity of lubricants used.

Value of lubricants used.

Square feet of lubricated surface rubbed over.

The power losses due to friction.

The power losses in cylinders and valves due to leakage and poor steam distribution caused by worn parts.

The cost of material and labor in making renewals of parts due to unusual friction wear.

The delay to machinery while making such renewals.

Irrespective of the price of lubricants or of any specifications that may be used, a really efficient lubricant must meet the following requirements:

1. It must be of sufficient body to keep the bearing surfaces apart at working temperatures.
2. It must possess lubrication qualities that will reduce friction to a minimum.
3. It must remain fluid at the lowest temperatures that are met with under ordinary service conditions.
4. It must meet service requirements as to durability, resistance to elements, usage, etc.
5. It must contain no impurities which would corrode or pit the bearing surfaces.
6. It must have no tendency to decompose or form deposits which may gum up the bearings.
7. It must be of sufficient capillarity to feed evenly and successfully, with little change in this respect when encountering natural changes in atmospheric temperatures.

These essentials as a guide for selection apply with equal importance to practically every class of machinery requiring lubrication—from the automobile to the modern locomotive. There can be no compromise on quality, nor neglect of the necessary details of care, if really efficient service is to be secured. I venture to say that there has never been an instance where skimping on lubrication quality did not prove to be an expensive policy or experiment.

This is particularly true of heavy machinery, where lubricants are called upon to bear extraordinary weights and strains. For average requirements or even with large consumers, there is really very little money differences between the initial cost of reliable, high-grade oils and those physically unsuited for the work. But there is a much greater difference when comparative service results are analyzed. Any sacrifice in quality to accomplish a tentative saving will invariably result in the user's paying twice over for his lubrication as a penalty for using poor judgment in doing so.

Annual Report of the Chief Inspector Bureau of Locomotive Inspection

By A. G. Pack, Chief Inspector, Bureau of Locomotive Inspection

A synopsis is given, by railroads, of all accidents, showing the number of persons killed and injured due to the failure of parts and appurtenances of the locomotive and tender, including the boiler, as reported and investigated under section 8 of the locomotive inspection law, and those reported to the Bureau of Statistics under the accident report act of May, 1910, and not reported to this bureau as should have been.

The data contained herein cover all defects on all parts and appurtenances of the locomotive and tender, including the boiler, found and reported by our inspectors, arranged by railroads.

The tables show the number of accidents, the number of persons killed and number injured as a result of the failure of parts and appurtenances of the locomotive and tender, including the boiler.

Tables have been arranged so as to permit comparison with previous years as far as consistent and also show the number of locomotives inspected, the number and percentage of those inspected and found defective, the number for which the written notices for repairs were issued in accordance with section 6 of the law withholding them from service because of being in violation of the law, and the total defects found and reported.

LOCOMOTIVE REPORTS AND INSPECTIONS

	1926	1925
Number of locomotives for which reports were filed	69,173	70,361
Number inspected	90,475	72,279
Number found defective	36,354	32,989
Percentage inspected found defective	40	46
Number ordered out of service	3,281	3,637
Total number of defects found	136,973	129,239

ACCIDENTS AND CASUALTIES

	1926	1925
Number of accidents	247	274
Number of persons killed	18	13
Number of persons injured	287	315

Investigation of Accidents

All accidents reported to this bureau, as required by the law and rules, were carefully investigated and action taken to prevent recurrences as far as possible. Copies of accident investigation reports were furnished to parties interested when requested, and otherwise used in an endeavor to bring about a decrease in the number of accidents.

A summary of all accidents and casualties to persons as compared with the previous year shows a decrease of 16.8 per cent in the number of accidents, an increase of 10 per cent in the number of persons killed, and a decrease of 13.6 per cent in the number injured during the year. There was also a substantial decrease in the percentage of locomotives inspected by our inspectors found defective. During the year 40 per cent of the locomotives inspected were found with defects or errors in inspection that should have been corrected before being put in use as compared with 46 per cent for the previous year and 53 per cent for the fiscal year ended June 30, 1924.

While there was a substantial decrease in the total number of accidents during the year, our investigations indicate that a still greater decrease should have resulted had the requirements of the law and rules been complied with, especially so with respect to defects the repair of which are frequently considered unimportant.

Boiler explosions caused by crown-sheet failures continue to be the most prolific source of serious and fatal accidents with which we have to deal, 72.7 per cent of the fatalities during the year being attributable to this cause. The importance of properly maintaining water-level indicating appliances that will accurately register the water level in the boiler under all conditions of service, and which may be easily and accurately observed by the occupants of the locomotive cab from their usual and proper positions, cannot be overemphasized. The use of the strongest practicable fire-box construction, especially within the area which may be exposed to overheating due to low water, and the application of a device that will give no audible alarm when the water level approaches the danger point, would be distinct steps forward in the reduction of accidents and casualties resulting from crown-sheet failures. Further reference is made to audible low-water alarms elsewhere in this report.

Reduced Body Stay Bolts

Our investigations of reduced body stay-bolt breakage show that failure most frequently occurs in the reduced body at or close to the fillet joining the body of the bolt and the enlarged ends, and telltale holes which do not extend into the reduced section at least five-eighths of an inch cannot be depended upon to indicate broken bolts.

A great majority of broken staybolts are found by leakage through telltale holes without the aid of the hammer test. The sound and vibration when staybolts are hammer tested varies with the location of the bolts in the firebox and also with the shape of the firebox. Inspectors depend upon the telltale holes as a check of the results of the hammer tests. If the telltale holes do not extend into the bolts to or beyond the usual point of breakage, they are not only useless as a safety feature, but become a distinct menace to safety.

Extension of Time for Removal of Flues

One hundred and twenty-six applications were filed for extension of time for removal of flues, as provided in Rule 10. Investigation disclosed that in 12 of these cases the condition of the locomotives was such that no extension could properly be granted. Twelve were in such condition that the full extension requested could not be authorized, but an extension for a shorter period was allowed. Twenty extensions were granted after defects disclosed by investigation had been repaired; 13 application were canceled for various reasons; 69 extensions granted for the full period requested.

Specification Cards and Alteration Reports

Under Rule 54, 1,860 specification cards and 10,378 alteration reports were filed, checked, and analyzed. These reports are necessary in order to determine whether or not the boilers represented were so constructed or repaired as to render safe and proper service and whether the stresses were within the allowed limits. Corrective measures were taken with respect to numerous discrepancies found.

Under Rule 328 of the Rules and Instructions for Inspection and Testing of Locomotives Other Than Steam, 274 specification cards and 5 alteration reports were filed. These were carefully checked and analyzed and corrective measures taken with respect to the discrepancies found.

Prosecutions—No prosecutions for violations of the locomotive inspection law were instituted during the year.

Three cases which were pending at the beginning of the year were disposed of. Judgment was assessed against the carrier in one case, one case was compromised upon payment by the carrier of the penalties sued for, and judgment was rendered by the court in favor of the defendant in the third case.

Appeals—Three formal appeals were taken from the decisions of our inspectors during the year, two of which were dismissed. Two items were involved in one of the appeals, one of which was dismissed while the carrier was sustained in the other.

Rules and Instructions for Inspection and Testing of Locomotives Other Than Steam

In conformity with the established practices in the formulation of rules and instructions, conferences were held with interested parties and a code of rules for inspection and testing of locomotives other than steam was formulated and agreed upon, which was approved by order of the commission, dated December 14, 1925, and made effective July 1, 1926.

In my former reports recommendations were made, in accordance with section 7 of the act, as amended, for the application of automatic fire doors, power reverse gears, power grate shakers, automatic bell ringers, horizontal hand holds, stirrups on cabs, and water columns with water glass and gauge cocks attached with an additional water glass located on the left side or boiler back head, and reasons therefor given.

Many of the carriers are recognizing the value in the promotion of safety, efficiency, and economy of these appliances and are complying with the recommendations in many cases, while others are not therefore the recommendations are respectfully renewed and should be made a requirement of the rules.

Low-Water Alarms

Audible low-water alarms are now being experimented with very successfully and are being applied by many of the carriers. The general application of a dependable low-water alarm would be of inestimable value in reducing the number of serious and fatal accidents caused by explosions. It is felt that the carriers can make no greater contribution to the safety of locomotive operation than by continuing to assist in the development of these devices to the extent that they may become wholly dependable in warning the engineman when water becomes dangerously low in the boiler.

New York Central's Oil-Electric Tug

The most powerful oil-electric tugboat in the world has been placed in service in New York Harbor by the New York Central Railroad Company, where it will be used for towing barges and carfloats. Following official tests, the new tugboat, known as "New York Central Lines No. 34," made a number of short cruises in the Harbor on January 26th. The cruises were attended by representatives of the Federal and City governments and many prominent officials of railroad.

Eight outstanding advantages of this type of tugboat were pointed out by Frederick W. O'Neil, Chief Engineer of the Ingersoll-Rank Company in an interview. These are: bridge control, constant full-load power, excellent torque performance, economical generation of power, decreased engine weight, power reserves, savings in service time and reduced operating costs. From the bridge positive an accurate control of the boat is made possible, control signals to the engine room are eliminated. By bridge control the possibility of damage to docks, to the tugboat itself and to other craft is practically eliminated.

If the engine and propeller are directly connected, the engine when driving the boat without a tow runs at a certain speed taking the full power of the engine and drives the tug, say 10 or 12 miles per hour. When the tug is fastened to a tow it will obviously run slower, say 5 or 6 miles per hour, depending upon the size of the tow. In this case it is not possible to drive the propeller at the high speed used when the ship was free. A lower propeller and engine speed must be used to correspond to the lower speed of the ship. This means a reduction of horsepower, that is, the full power of the engine is not available. This is the condition when the vessel should be doing its most effective work. In the oil-electric, however, the engines run at a constant speed, driving the generator so that the generator can always put out the full power of the oil engines. When the propeller is turning slowly for towing, the electrical hook-up is such that the power given the propeller can be made correspondingly larger as the speed is less so that in effect the propeller can push as much horse power while towing as when running at high speed without a tow.

The proper speed for a propeller is a function of the size and type of the ship. In the oil-electric drive the propeller can be run at any speed to suit the ship for it need not be run at the same speed as the engines. The engines therefore can be a high speed type used for generating power, which makes them lighter and more efficient. In other words, one can have the proper propeller for the ship and the proper engine for the most economical generation of power. When the engine is directly connected a compromise is made between the most desirable propeller for speed and the proper engine speed. This results in the selection of an engine whose speed is comparatively slow and which makes it large in size and weight. The oil-electric type with an electrical hook-up between the propeller and the oil engines is like a set of gears which have an infinite number of speed reductions.

The weight of the oil engines of the oil-electric tugboat is less than the power plant needed for securing the same power in a steam tugboat. The space occupied by oil-engines is less. And, in addition, smoke is eliminated; there are no ashes or boilers, and tanks for fresh water are eliminated.

Due to time saved in fueling and in the elimination of the need for disposing of ashes and cleaning boilers, in the saving of time necessary to get up steam and in its ability to start and stop immediately, the oil-electric tug is in service a greater part of the time than is the case with the steam tug.

Because of its reduction of fuel costs, of its ability to be in service more frequently than the steam tug and the need for fewer operators, it has been estimated that the yearly operating expense, including all charges on the investment, is approximately 20 per cent lower than for a steam tug of the same power. It has been estimated that this saving will in 2½ or 3 years make up for the higher initial cost of the oil-electric as compared with the initial cost of the steam tug.

"New York Central Lines No. 34" was designed by I. W. Millard and Brothers, and built and outfitted by the Staten Island Shipbuilding Corporation. The hull, with a length overall of 108 ft. 3¼ in. and a 26 ft. beam was launched on October 15, 1926. Miss Jennie M. Hutter of the New York Central Lines Marine Department acted as sponsor. The oil-electric power of the boat consists of two Ingersoll-Rand type PR, 6 cylinder, 4 cycle, solid injection 14 x 19 oil engines, each direct connected to a 270 K.W. General Electric compound wound generator and 30 K.W. exciter.

These oil engine generating sets operate non-reversing at a constant speed of 265 r.p.m. The generators are connected in series and normally supply 480 volt direct current for the 650 S.H.P. double armature, shunt wound propulsion motor. The motor is direct connected to the propeller shaft and is capable of delivering full power of 650 S.H.P. at any speed from 115 to 145 R.P.M.

Another novel fature of the tugboat's construction is its control, which at all times is entirely in the hands of the captain in the pilot house. The importance of accuracy in the transmission of the signals to start, stop or reverse, used in connection with the operation of ordinary craft is well known. The safety of property and of the lives of the passengers are involved. Therefore, this feature of the oil-electric tug, in which the captain or pilot directly handles the propelling mechanism instead of signalling to an enigneer for manipulation of the engines is a real step forward. The boat, designed particularly for ease of handling in congested waterways, can turn around in its own length, while in pulling power it is said to set a new mark in tugboat service.

Notes on Domestic Railroads

Locomotives

The Missouri Pacific Railroad has ordered 5 Mountain type and 15 eight-wheel switching locomotives, also 6 Pacific type and 5 eight-wheel switching type locomotives for Gulf Coast Line, and 5 eight-wheel switching locomotives for the International Great Northern Railroad from the American Locomotive Company.

The Huntington & Broad Top Mountain Railroad has ordered 2 consolidation type locomotives from the Baldwin Locomotive Works.

The Canadian National Railways is inquiring for 4 Mountain type locomotives, 10 eight-wheel switching locomotives, 20, 2-8-4 type locomotives and 40, 4-8-4 type locomotives.

The New Orleans Great Northern Railroad has ordered 3 Mountain type locomotives from the American Locomotive Company.

The Oliver Iron Mining Company is inquiring for 12 eight-wheel switching type locomotives.

The New England Fuel & Transportation Company has ordered one eight-wheel switching locomotive from the American Locomotive Company.

The Atchison, Topeka & Santa Fe Railway has ordered 10 Santa Fe type oil-burning locomotives from the Baldwin Locomotive Works.

The Mobile & Ohio Railroad has ordered 5 six-wheel switching type locomotives from the American Locomotive Company. These locomotives will have 21 by 28 in. cylinders and a total weight of 165,000 pounds in working order.

The Youngstown & Northern Railroad is inquiring for 2 six-wheel switching locomotives.

The Boston & Maine Railroad is planning for 26 locomotives which will include one direct drive Diesel locomotive. The road will obtain the Diesel locomotive from the Fried Krupp Works, Germany, as a trail locomotive, which will be the first direct drive Diesel locomotive to be operated in this country. It will be of from 1,300 to 1,450 horse-power, will have a tractive force of 50,000 pounds and a total weight of 314,000 pounds.

Freight Cars

The Atchison, Topeka & Santa Fe Railway has ordered 150 sulphur cars from the American Car & Foundry Company.

The Baltimore & Ohio Railroad has ordered 500 box cars from the American Car & Foundry Company and 500 box cars from the Pressed Steel Car Company.

The Union Carbide Company is inquiring for 2 flat cars of 30 tons capacity.

The Chicago & North Western Railway is inquiring for 500 steel under-frames and superstructure material for box cars.

The Chicago, Burlington & Quincy Railroad has ordered 500 box cars from the Pullman Car & Manufacturing Corporation.

The Northern Pacific Railroad is inquiring for 200 ballast cars.

The Mobile & Ohio Railroad has ordered 250 steel underframes flat cars, 200 steel frame hopper cars and 250 steel frame gondola cars of 50 tons capacity, from the Chickasaw Shipbuilding Corporation.

The Union Refrigerator Transit Company has ordered 500 refrigerator cars from the American Car & Foundry Company.

The Atlantic Coast Line Raiload is inquiring for 50 steel underframes.

The Chicago & North Western Railway is inquiring for 500 hopper cars of 50 tons capacity.

The Great Northern Railway has ordered 25 tank cars from the General American Tank Car Corporation.

The Baltimore & Ohio Railroad has ordered 100 underframes and superstructures for caboose cars to be built in the Baltimore & Ohio shops from the Pressed Steel Car Company.

The Chicago & North Western Railway is inquiring for 500 hopper cars.

The Oliver Iron Mining Company is inquiring for 35 ore cars of 70 tons capacity.

The Southern Pacific System is inquiring for 200 tank cars and 1,000 general service cars.

The Swift & Company, Chicago, Ill., is inquiring for 300 refrigerator cars and 300 underframes.

The Union Refrigerator Transit Company has ordered 500 refrigerator cars from the American Car & Foundry Company.

The Buffalo, Rochester & Pittsburgh Railway is having repairs to 500 gondola cars done by American Car & Foundry Company.

The Atchison, Topeka & Santa Fe Railway is inquiring for 50 Enterprise ballast cars.

The Wabash Railway has ordered 500 automobile box cars from the American Car & Foundry Company and 500 from the Standard Steel Car Company.

The Bangor-Aroostook Railroad is reported as going to build 100 cars in its own shops.

The Nevada Consolidated Copper Company is inquiring for 20 ore cars of 60 tons capacity.

The Norfolk & Western Railroad is inquiring for 50, 30 cubic-yard air dump cars.

The Canadian National Railways is inquiring for 1,000 steel frames box cars of 60 tons capacity.

The Burlington Refrigerator Express has ordered 200 steel nuderframes from the Ryan Car Company.

The Baltimore & Ohio Railroad has ordered 1,000 hopper cars trom the Bethlehem Steel Company and 1,000 from the Standard Steel Car Company.

The Southern Pacific Company is inquiring for 500 sets of steel underframes and superstructures for box cars.

The Tide Water Oil Company has ordered 200 tank cars of 8,000 gal. capacity from the American Car & Foundry Company.

The Goodwin, Gallagher Sand & Gravel Corporation has ordered 8 all steel hopper cars of 20 tons capacity from the Magor Car Corporation.

The Chicago, Rock Island & Pacific Railway has ordered 250 hopper ballast cars from the Pressed Steel Car Company.

Passenger Cars

The Wabash Railway is inquiring for 12 combination passenger and baggage cars, 10 chair cars, 8 coaches, 6 dining cars, 2 cafe chair cars and 4 lounge cars.

The Atchison, Topeka & Santa Fe Railway has ordered 10 baggage cars from the Pullman Car & Manufacturing Corporation.

The Chicago, Aurora & Elgin Railroad has ordered 15 motor equipped passenger cars from the Cincinnati Car Company.

The Canadian National Railways is inquiring for 25 coaches, 13 dining cars, 26 standard sleeping cars, 4 combination baggage and smoking cars and 12 baggage cars.

The Chicago, Milwaukee & St. Paul Railway is inquiring for 10 gasoline-electric cars.

The Chicago, Burlington & Quincy Railroad is inquiring for 11 gasoline electric motor cars.

The Chicago, South Shore & South Bend Railroad has ordered 10 motor cars and 10 trailers from the Pullman Car & Manufacturing Corporation.

The Mobile & Ohio Railroad has ordered 2 rail motor trailer cars from the J. G. Brill Company, Philadelphia, Pa.

The Gulf, Mobile & Northern Railroad has ordered 2 steel passenger coaches from the American Car & Foundry Company.

The Chicago, Milwaukee & St. Paul Railway has ordered 5 passenger-baggage motor car bodies 72 ft. long with 19 ft. baggage space and 44 passenger seats. The cars will be equipped with the Electric Motive Company's Model 120-275 horse-power gas-electric engine.

The New York Central Railroad is inquiring for 19 gas-electric rail motor cars 70 ft. long.

The Chicago & North Western Railway has ordered 40 suburban cars from the Standard Steel Car Company, 40 from the Pullman Car & Manufacturing Corporation and 20 suburban cars and 20 combination passenger and baggage cars from the American Car & Foundry Company.

The Mobile & Ohio Railroad has ordered 6 coaches from the

Pullman Car & Manufacturing Corporation, 6 baggage cars and one combination passenger baggage and mail car from the American Car & Foundry Company.

The Canadian National Railways is inquiring for 2 combination mail and express cars and 6 baggage cars.

The Chicago, Rock Island & Pacific Railway has ordered 5 dining cars and 10 coaches from the Pullman Car & Manufacturing Corporation.

The Baltimore & Ohio Railroad has ordered one combination passenger and baggage electric rail motor car from the J. G. Brill Company, Philadelphia, Pa.

The Mobile & Ohio Railroad has ordered 2 dual power combination mail, baggage and passenger gas-electric rail motor cars and one single power combination mail, baggage and passenger gas-electric rail motor car from the Electro Motive Company.

The Missouri Pacific Railroad has ordered 6 chair cars and 4 baggage cars for the Gulf Coast Line and 4 chair cars and 2 baggage cars for the International Great Northern Railroad and 10 baggage cars for the Missouri Pacific Railroad from the American Car & Foundry Company, also 7 dining cars, 16 coaches and 3 combination cafe-club cars from the Pullman Car & Manufacturing Corporation; 10 combination baggage and passenger cars and 8 combination mail and baggage cars from the St. Louis Car Company.

Buildings and Structures

The Canadian Pacific Railway will construct new engine terminal and shop facilities at Toronto, Ontario, to cost approximately $3,000,000. The Frisco System plans to expend about $100,000 on new mechanical facilities at its car shops at Yale, Tenn., near Memphis. The company is also building new repair shops at Pensacola, Fla. The company plans to expend $169,300 on interlocking towers on its lines in Kansas, Arkansas, Oklahoma and Missouri.

The Chicago, Burlington & Quincy Railroad has awarded a contract for the construction of a three-story passenger station and office building at Lincoln, Nebr. The operating engineering and mechanical fores now located at Lincoln will be housed in the office building.

The Baltimore & Ohio Railroad has awarded a contract for the construction of an extension to its roundhouse at Willard, Ohio, to cost approximately $35,000.

The Chicago, Indianapolis & Louisville Railway has authorized the construction of a locomotive repair shop at Lafayette, Ind., estimated to cost about $275,000.

The Atlantic Coast Line Railroad has let contracts for the construction of sixteen miles of railroad from Thonotosassa, Fla., to Richland, Ga. The route being built to eliminate the necessity of traveling by way of Lakeland over the west coast route into Tampa and will shorten the route about fifty miles.

The Great Northern Railway has awarded a contract for the installation of electrical equipment on the line to be electrified between Skykomish and Wenatchee, Wash.

The Mobile & Ohio Railroad has awarded a contract for the construction of a 400-ft. elevator conveyor at Mobile, Ala., to cost approximately $15,000.

The New York Central Railroad has awarded a contract to the Roberts & Schaefer Company, Chicago, Ill., for the installation of a multiple pit "N. & W." type standard electric cinder plant at Corning, Ohio.

The Baltimore & Ohio Railroad has awarded a contract for the construction of a new freight house and driveway on the Cincinnati, Indianapolis & Western Railroad at Indianapolis, Ind., to cost about $38,000.

The Pennsylvania Railroad has awarded a contract to the Electro Construction Company for electric wiring for its new tank shop at Altoona, Pa., to cost approximately $31,000.

The Chicago, Milwaukee & St. Paul Railway has been authorized by the Federal Court at Chicago to drill a soft water well and to construct a 12 ft. by 24 ft. pump house, including pump and piping at Lavina, Mont., and to construct a hot water washing plant to serve a 35-stall roundhouse in Chicago at a cost of $53,400.

The Pennsylvania Railroad has awarded a contract for the removal of the two-story brick Pullman building at Thirty-second and Market streets, Philadelphia, in connection with its terminal improvement program at that point.

The New York Central Railroad has awarded a contract for work in connection with the construction of an automatic substation at Harmon, New York, at an approximate cost of $55,000. A contract has also been awarded for work in connection with bridge over Pocantico creek, Philipse Manor, New York, to cost $35,000.

The Chesapeake & Ohio Railroad has closed bids for the construction of a water station at Griffith, Ind.

The Grand Trunk & Western Railway plan for the construction of a rectangular enginehouse 52 ft. by 160 ft. at Harvey, Ill.

The Missouri Pacific Railroad has awarded a contract for the construction of a locomotive repair shop, 112 ft. by 81 ft., at Harlingen, Texas. Total expenditures for repair facilities and improvements at this point are to cost approximately $400,000.

The Pennsylvania Railroad has awarded a contract for the construction of coaling and water facilities and additional sidings at East Rochester, Ohio, to cost approximately $160,000.

The Wabash Railway is preparing plans for the construction of a grain elevator, at North Kansas City, Mo., which with conveying, hoisting and screening machinery is expected to cost approximately $500,000.

The Atchison, Topeka & Santa Fe Railway is preparing plans for the construction of a locomotive repair shop, blacksmith shop, storehouse, office building and trackage facilities at Phoenix, Ariz.

The Southern Pacific Railroad has awarded a contract for the construction of a reinforced concrete warehouse at Bakerfield, Calif., at a cost of about $41,000. The total expenditure for improvement at this point will cost approximate $187,000.

The Denver & Rio Grande Western Railroad has awarded a contract to the Roberts & Schaefer Company, for the construction of "N. & W." type electric cinder pits at Minturn, Colo., Grand Junction and Salt Lake City, Utah, at a cost of $40,000.

The Canadian Pacific Railway has awarded a contract for the construction of a 40-ton mechanical coaling station and enclosed water tank and a 30-ft single track cinder pit at Kimberly, B. C., Canada.

The Central Vermont Railway has awarded a contract to the Roberts & Schaefer Company, Chicago, Ill., for the installation of electric hoisting machinery at the coaling station at Burlington, Vt.

Supply Trade Notes

Edward H. Mattinglew, formerly representative of the **Chicago-Cleveland Car Roofing Company,** has been appointed representative of the **Bradford Corporation,** New York City, with headquarters at Chicago.

Henry C. Darby has been appointed sales representative of the **Inland Steel Company,** with headquarters at Kansas City, Mo.

J. O. Dearth has been appointed district sales manager of the **Central Alloy Steel Corporation,** Massillon, Ohio, with headquarters at Cincinnati, Ohio.

Edwin Besuden has been appointed to the sales department of the **National Railway Appliance Company** as a special representative, with headquarters at the Grand Central Terminal, New York City.

R. H. Wagner has been placed in charge of the **Link-Belt Company** office at New Haven, Conn.

The American Steel Foundries Company has secured control of the **Verona Steel Castings Company** of Verona, Pa.

The Magor Car Corporation, 30 Church street, New York City, has opened a new office at 133 West Washington street, Chicago, the office having been placed in charge of **W. P. Meigs.**

A. N. Martin has been appointed vice-president of the **Pyle National Company,** with headquarters at New York City.

Henry F. Gilg, formerly sales manager of the **Penn Iron & Steel Company,** Pittsburgh, Pa., has been appointed general agent of railroad sales of the **Atlas Steel Corporation,** with headquarters at Pittsburgh.

The Worthington Pump & Machinery Corporation has bought the **Harris Air Pump Company.** The purchase was outright and includes patents, drawings, patterns and good-will.

John T. Carroll, general superintendent of motive power and equipment of the Baltimore & Ohio Railroad, has resigned and has entered the railway supply business with office at Citizens National Bank building, Baltimore, Md.

Donald G. Clark, eastern manager of the **Ferth Sterling Steel Company,** has been appointed a director of the company. Mr. Clark joined the company in 1903 and was the resident manager at Pittsburgh from 1910 to 1913. In 1919 he took charge of the company's business in the east, with headquarters at New York City, and has done much to introduce stainless steel in that section.

W. F. Beyer has been appointed agent for the **Greenfield Tap & Die Corporation,** in charge of the western territory, with headquarters at St. Louis, succeeding **Fred M. Bettes,** deceased.

The Western Electric Company has organized the **Electrical**

Research Products, Inc., of Wilmington, Del., as a subsidiary corporation to take over that portion of Western Electric business which is not related to the manufacture and distribution of telephone apparatus and supplies for the Bell system. The Electrical Research Products, Inc., will have charge of the commercial development of electrical devices and inventions controlled by the parent company and not suitable for distribution through the **Graybar Electric Company.** Its subsidiary operating in the distribution of the electrical supplies. **J. E. Otterson,** general commercial manager of the Western Electric has been appointed general manager of Electrical Research Products, Inc., with headquarters at 195 Broadway, New York.

Edwin H. Pierce has been elected vice-president and general manager of the **Niles Tool Works Company,** with headquarters at Hamilton, Ohio, and will be the assistant to **James K. Cullen,** president of the Company. **The Railway Steel Spring Company,** closed its office in Norfolk, Va. The business of this district will hereafter be handled by Ross Anderson district sales manager for **American Locomotive Company,** at Richmond, Va. **The Pullman Company** will be reorganized through the formation of a holding company to take over the **Pullman Company** and the **Pullman Car & Manufacturing Corporation.** A committee was appointed to carry out a plan for the reorganization.

J. F. Prettyman & Sons are now building a large creosoting plant at Charleston, So. Car., which it is estimated will have capacity for treating 55,000,000 feet of timber annually and provides storage space for 1,000,000 ties in addition to a large area for seasoning of piles, poles and other timber.

Harry E. Miller, assistant works manager of the Newark, N. J., plant of the **Westinghouse Electric & Manufacturing Company,** has been promoted to works manager of the plant.

George B. Powell, sales agent for the **Railway Steel Spring Company** at St. Louis, now has the Louisville territory, and the office at that point is discontinued. The Pacific Coast territory is now handled by **W. E. Corrigan** district sales manager of the **American Locomotive Company,** with headquarters at San Francisco. **A. W. Sullivan,** sales agent for the **Railway Steel Spring Company,** has moved his office in Pittsburgh to the Farmers Bank building.

C. E. McGregor, formerly representative of the **Republic Flow Meters Company,** has been appointed representative of the **Brown Instrument Company,** Philadelphia, with headquarters at Chicago.

H. M. Wey, formerly district manager of the **Pittsburgh Testing Laboratories,** with headquarters at Chicago, has been appointed representative of the Wellsworth safety division of the **American Optical Company,** with headquarters at Chicago.

C. O. Jones, sales manager of the power transformer section of the **General Electric Company,** for many years, has been appointed assistant to the manager of the transformer division. **L. L. Biche,** assistant sales manager of the section has been appointed sales manager.

The North American Car Corporation has purchased the plant of the **North Judson Car & Equipment Company,** and will use the plant for the repair and distribution of their tank cars, refrigerators and the poultry cars of the **Palace Poultry Car Company,** one of its subsidiaries.

Joseph H. Young, formerly president of the Denver & Rio Grande Western, has been appointed assistant vice-president of the **Union Switch & Signal Company,** with headquarters at Chicago.

Items of Personal Interest

R. J. Bowman has been appointed assistant to the president of the Erie Railroad, with headquarters at New York City.

J. D. Farrell has retired as vice-president of the Oregon-Washington Railroad and Navigation Company and the Yakima Valley Transportation Company.

Alexander C. Shand, chief engineer of the Pennsylvania Railroad, with headquarters at Philadelphia, has been appointed assistant to the vice-president, with the same headquarters.

L. C. Sprague, general manager of the Uintah Railway, has been appointed vice-president, with headquarters at Mack, Colo.

W. J. Fripp has been appointed assistant vice-president of the New York Central Railroad, with headquarters at New York City.

Columbus Haile has been appointed president of the Missouri-Kansas-Texas Railroad, with headquarters at St. Louis, and **George T. Atkins** has been appointed vice-president in charge of traffic.

J. T. Wallis, chief of motive power of the Pennsylvania Railroad, with headquarters at Philadelphia, has been appointed assistant vice-president of operation, with the same headquarters. **C. M. Sheaffer,** chief of transportation, with headquarters at **Philadelphia,** has been appointed to assistant vice-president of operation, with the same headquarters.

Homer E. Meyer has been appointed vice-president and general manager of the Missouri-Kansas-Texas Railroad, with headquarters at Dallas, Texas, succeeding **W. M. Whitetenton,** resigned.

B. L. Bugg has been appointed president of the Atlanta, Birmingham & Atlantic Railway under the new reorganization company; **Lyman Delano** and **J. L. Edwards** are vice-presidents. **A. V. B. Gilbert** is purchasing agent and assistant secretary; **H. L. Borden** is secretary and assistant treasurer.

John T. Carroll, general superintendent of motive power and equipment of the Baltimore & Ohio Railroad with headquarters at Baltimore, has resigned to go into business for himself.

J. R. Agnew has been appointed road foreman of engines of the Washington division of the Southern Railway, with headquarters at Alexandria, Va.

A. J. Herner has been appointed lubrication engineer of the Union Pacific Railroad, with headquarters at Omaha, Nebr.

J. B. Graham has been appointed master mechanic of the Missouri Pacific Railroad, with headquarters at Wichita, Kans., succeeding **J. P. Downs,** resigned.

Lucius Seam has been appointed master mechanic of the Cooper Range Railroad, with headquarters at Houghton, Mich., succeeding **Gibson Bisson,** resigned.

V. N. Potts has been appointed general foreman of the Gulf Coast Line Shops at Kingsville, Tex., **J. M. Firebaugh** is appointed roundhouse foreman, and **H. M. Woolston** is appointed erecting shop foreman.

W. O. Thompson, formerly general superintendent of rolling stock of the New York Central Railroad, with headquarters at Buffalo, New York, has been appointed assistant of equipment, with the same headquarters.

R. H. Flinn, master mechanic on the Western region of the Pennsylvania Railroad, with headquarters at Columbus, Ohio, has been promoted to superintendent of motive power of the Northern division Central region, with headquarters at Buffalo, New York.

Harry F. Lacey has been made general foreman of the Frisco Line Shops at Ft. Scott, Kans. succeeding **H. E. Bassett,** retired.

August Mueller, in addition as supervisor of automatic train control of the Chicago, Rock Island & Pacific Railway, has been appointed air brake instructor, with headquarters at Chicago, succeeding **W. J. Hartman,** recently deceased.

J. E. Gardner, electrical engineer of the Chicago, Burlington & Quincy Railroad, will have general supervision of electrical construction, installation and maintenance of electrical equipment in the mechanical department and supervision of both inspection and maintenance of electrical equipment in the operating departments, other than signal and telegraph.

W. H. Flynn, general superintendent of motive power of the New York Central Railroad lines East and West of Buffalo, N. Y., with headquarters at New York City, has been appointed general superintendent of motive power and rolling stock, with the same headquarters.

T. Devaney has been appointed shop superintendent of the New York, Chicago & St. Louis Railroad, with headquarters at Frankfort, Ind.

E. W. Brown has been appointed general foreman of the Frisco Lines, with headquarters at West Tulsa, Okla., and **Claude L. Holmes** has been appointed night roundhouse foreman at Memphis, Tenn., succeeding **J. R. Hirsch.**

T. W. Coe, master mechanic on the Nickel Plate division of the New York Chicago & St. Louis Railroad, with headquarters at Conneaut, Ohio, has been promoted to superintendent of motive power, with headquarters at Cleveland, Ohio, succeeding **W. G. Black,** who has resigned.

F. Kerby, supervisor of locomotive operation of the Baltimore & Ohio Railroad, with headquarters at Cumberland, Md., has been appointed assistant to the chief of motive power and equipment, with headquarters at Baltimore, Md.

George Thomas has been appointed boiler foreman of the Union Pacific Railroad, with headquarters at Evanston, Wyo.

F. W. Hankins, general superintendent of motive power of the Central region of the Pennsylvania Railroad, with headquarters at Pittsburgh, Pa., has been promoted to chief of motive power, with headquarters at Philadelphia, succeeding **J. T. Wallis.**

A. W. Turner, road foreman of engines of the Michigan Central Railroad, with headquarters at Jackson, Mich., has been appointed master mechanic, with headquarters at Niles, Mich., succeeding **W. H. Corbett,** who has retired.

T. G. Delph, chief clerk to the superintendent of the Atlanta division of the Nashville, Chattanooga & St. Louis Railway, with headquarters at Atlanta, Ga., has been appointed terminal trainmaster of the Atlanta Terminals.

W. G. Black, formerly superintendent of motive power of the New York, Chicago & St. Louis Railroad, has been appointed mechanical assistant to the president of the Erie Railroad, with headquarters at Cleveland, Ohio.

O. W. Campbell, superintendent of car service of the Missouri-Kansas-Texas Railroad, with headquarters at Denison, Texas., has been appointed superintendent of transportation, with the same headquarters.

Lawrence Richardson has been appointed assistant to the president of the Boston & Maine Railroad, with headquarters at East Cambridge, Mass.

George D. Eddy, assistant engineer with the President's Committee on Federal Valuation of Railroads, with headquarters at Chicago, has been appointed valuation engineer of the St. Louis-San Francisco Railway, with headquarters at St. Louis, Mo.

Obituary

Colonel Henry Goslee Prout, formerly editor-in-chief of the "Railroad Gazette," now "The Railway Age," died at his home in Summit, New Jersey, on January 26th, after an illness of many months. He retired from active business in 1915.

Colonel Prout was born at Falls Village, Virginia, in 1845. During the Civil War he served with the 57th Massachusetts Volunteers. He attended the University of Michigan and after his graduation in 1871 commanded an expedition of reconnoissance in southwestern Colorado. He also served under General Barlow on the first government survey which determined the boundaries of Yellowstone Park. It was at Colonel Prout's suggestion that the famous geyser was named "Old Faithful."

His survey work brought him to the attention of General Sherman, and he was one of six young men who, at the request of the Khedive of Egypt, were recommended by General Sherman for military service there. He went to Egypt as major of engineers. He served with distinction under General Charles Gordon, whom he succeeded as Governor General of the Provinces of the Equator. Colonel Prout was the only American who has ever held the position of governor of an African province. He had authority over a vast territory, and with the exception of the Austrian, Emin Pasha, had no American or European officers under him.

After four years in Africa Colonel Prout returned to America. He was for sixteen years editor of "The Railroad Gazette," now "The Railway Age," and was a prominent figure in the railway and engineering world. Folloing his retirement from this magazine he was connected for twelve years with the Westinghouse interests at Pittsburgh.

He received the honorary degree of Master of Arts from Yale University in 1902 and in 1911 Michigan University made him Doctor of Laws.

His biography of George Westinghouse which he wrote in 1921 is perhaps one of the best indices of the character and spirit of the man. It is a literary monument, while at the same time a model of scientific accuracy and comprehensive judgment.

Emory H. Smith, son of the late A. H. Smith, president of the New York Central Railroad, died suddenly of heart trouble at home at New York city, in his fortieth year. He was born in 1886 at Adrian, Mich. After graduating from Yale University he became a partner in the metal firm of Vivian Bond & Co., of New York. In 1921 he resigned to become President of the Refrigerator Car Company. Mr. Smith was known among the railroad men through his position as president of the Merchants' Despatch, Inc., and the Merchants' Transportation Company, two New York Central Railroad subsidiaries which build and operate refrigerator cars.

Anson Wood Burchard, vice-chairman of the board of directors and chairman of the executive committee of the General Electric Company, and chairman of the board of directors of the International General Electric Company, died on January 22 in New York City. Mr. Burchard was born in Hoosick Falls, New York, on April 21, 1865. He graduated from Stevens Institute of Technology in 1885 with the degree of mechanical engineer. In 1902 he joined the organization of the General Electric Company and until 1904 was controller, with headquarters at Schenectady. In 1904 he was appointed assistant to the president. In 1912 he was elected a vice-president, and in 1917 was elected a member of the board of directors. In May, 1922, he was elected vice-chairman of the board, and in June of the same year he was elected president and chairman of the board of directors of the International General Electrical Company. A little over a year ago he was relieved of the duties of president, but continued as chairman of the board. Mr. Burchard was director of several utility and electrical companies.

Ernest Ocaranza Llano, formerly general director of the National Railway of Mexico, died of pleurisy on January 12 in his private car at the Union Station, St. Louis, Mo., while en route to Johns Hopkins hospital, Baltimore, Md., for treatment. Mr. Llano was elected general director in 1923, which position he held until his retirement in 1925.

A. M. Acheson, vice-president and chief engineer of the Waco, Beaumont, Trinity & Sabine Railroad, died at Dallas, Texas, on January 12th, in his 68th year. Mr. Acheson for many years has been identified with railway development in Texas and other states, and served the Missouri-Kansas-Texas Lines in many capacities. He was born at Washington, Pa., in 1858, and attended Washington and Jefferson College. Mr. Acheson entered railway service in 1880 as a rodman for the Lake Erie & Western. From 1881 until 1883 he was a levelman for the New York, West Shore & Buffalo. In 1883 he became transitman for the Pennsylvania System, continuing in this capacity for two years. Then he was engaged in surveys for projected railroads for two years, at the end of which time he became assistant engineer for the St. Paul, Minneapolis & Manitoba. After two years' service in this position he became assistant engineer at Denison and Dallas for the Missouri-Kansas-Texas, and after holding that position for 11 years he became resident engineer with headquarters in Dallas, Texas. In 1906 he became division superintendent for the Missouri-Kansas-Texas. He served in that capacity for 3 years and then was made chief engineer of the Missouri-Kansas-Texas. In 1913 he was made chief engineer of operation for the Missouri-Kansas-Texas and the following year became chief engineer of the system. From 1915 to 1923 he was division superintendent for the road with headquarters at Trinity. As an engineer for the road Mr. Acheson was instrumental in much constructive work, especially the road yards at Denison, Dallas and Belle Mead yards at Waco and the main line from Smithville to Houston. He was long convinced of the need for another line from North and Central Texas to East Texas and completed several such surveys for the Missouri-Kansas-Texas Lines.

James G. Bateman, assistant manager of sales of the National Tube Company, with headquarters at New York, and vice-president of the Engineers' Club, died on February 2 of pneumonia at the Engineers' Club. Mr. Bateman was born at Easton, Md., 1878. He served consecutively with Erie Railroad, The Symington Company and for a time in 1907 with the Delaware & Hudson Company at Albany, N. Y., and since that time had been associated with the National Tube Company.

New Publications

Books, Bulletins, Catalogues, Etc.

An Investigation of the Mechanism of Explosive Reactions. By Crandall Z. Rosecrans. This bulletin will be issued by the Engineering Experiment Station of the University of Illinois. For your convenience a brief review of the bulletin is given.

The numerous changes in the composition of liquid fuels for internal combustion engines and the tendency towards the employment of higher compression ratios, which frequently result in "fuel knock," have indicated the desirability of a more detailed and complete knowledge of the actual mechanism of the explosive reactions. A great amount of experimental work has been done on this problem, but there are so many phases of the general subject that it is difficult to consider more than one or two divisions of the problem in one investigation.

Bulletin No. 157 of the Engineering Experiment Station of the University of Illinois contains the report of an investigation, the purpose of which was to make a study of the flame propagation in a closed cylindrical bomb and to compare the results of a theoretical analysis of flame propagation with the actual phenomena as observed by means of photographic records. Furthermore, it was desired to investigate certain phenomena reported by other experimenters, such as the flame arrest and other obscure processes of explosive reaction.

The investigation was limited to the study of the explosion of mixtures of ethyl ether and air in a cylindrical bomb of constant volume. Two bombs of the same diameter but different lengths were used.

Among the conclusions drawn were the following:

The experimental results on the whole confirm the results of Woodbury, Lewis and Canby, that the flame fills the bomb at the time that maximum pressure is attained. However, this does not always appear to be the case.

The experimental results do not furnish any evidence of the dependence of the velocity of flame propagation on the initial temperature.

The flame arrest phenomenon appears in all the flame photographs, and occurs quite uniformly at about one-half the length of the bomb from the ignition point. At the time of the flame arrest the pressure had in general risen to about 25 per cent of the maximum.

From the characteristics of the expansion and compression of the burned and unburned gases, respectively, during an explosion, the existence of the afterburning and adjustment of chemical equilibrium behind the flame front has been demonstrated.

The results indicate that the reaction velocity is a function of the pressure. An equation expressing this relation has been suggested.

Copies of Bulletin No. 157 may be obtained without charge by addressing the Engineering Experiment Station, Urbana, Illinois.

The Heating and Ventilating Engineers' Guide.—The American Society of Heating and Ventilating Engineers has issued a book on the subject and the book contains design and specification data useful in the planning and ventilating installations. It was prepared and published by the society with the co-operation of a large and important committee of practicing heating and ventilating engineers. In addition to engineering and practical data, it contains a very useful and valuable advertising section which is carefully edited and in which the manufacturer gives information in reference to his product. The material in the more basic subjects has been prepared by engineers who are authorities in their particular fields. The publication contains 580 pages with numerous charts maps and tables. Copies can be had at office of the society, at New York, N. Y., at a charge of $3.00 per copy.

General Electric Review.—The January issue of the General Electric Review marks the introduction of a new standard size magazine, together with a general revision of the scheme of editorial make-up, and is made up principally of a review of the electrical industry for the year of 1926. Copies of the magazine may be obtained from the company.

Mechanical Drive Turbines.—The General Electric Company, describes in its Publication 578 Type D. mechanical drive turbines for centrifugal pumps. These turbines can be arranged to operate at steam pressures up to 400 lb. and steam temperatures up to 725 deg. F.

Steam Generators.—The La Mont Corporation, 200 Fifth avenue, New York City, has issued a 20-page booklet entitled, "The new way of making steam." The factors of gravity, adhesion, cohesion the relation of the steam bubble and surface tension as functioning in the old and new ways of making steam are analyzed and compared. The La Mont steam generator described is suitable for industrial furnaces of any character discharging waste gases at a heat of 750 deg. F. or over.

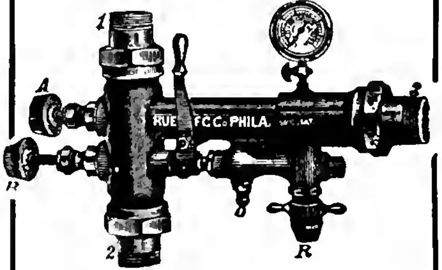
The Density of Carbon Dioxide with a Table of Recalculated Values. By Samuel W. Parr and William R. King, Jr. This circular will be issued by the Engineering Experiment Station of the University of Illinois.

Recalculated values for the density of carbon dioxide for temperatures from 10 to 30 degrees and pressures from 720 to 770 mm. were published in the Journal of the American Chemical Society, vol. 31, 1909. It was the purpose of this table to correct the errors which were inherent in the original Dietrich calculations first published in 1862 and which had become the common table of reference from that date. These newly calculated values, therefore, in the main, displaced those of the earlier Dietrich table. Following the publication of this table, however, a number of other factors entered into the case. For example, the Van Nostrand's Annual for 1922 contains an extended table, covering the same range of temperatures but including barometric pressures from 700 to 770 mm. This extension of the table to cover lower barometric pressures is not altogether consistent in its calculated values with the original part of the table. This fact in itself might not be sufficient argument for recasting the table. However, it was decided to extend it to cover a wider range of temperature, namely, from 10 to 35 degrees, and also to incorporate in the formula for deriving the values given a factor which would take account of the deviation of carbon dioxide from the gas laws. It was also deemed better to make the calculations for readings on a barometric brass scale than for readings on a glass scale.

This work was carried on by the Engineering Experiment Station of the University of Illinois under the direction of Prof. Samuel W. Parr and William R. King, Jr., and the results are published in Circular No. 13, entitled "The Density of Carbon Dioxide with a Table of Recalculated Values." This circular describes the method of developing the formula for obtaining the weight of carbon dioxide, and contains a table of new values. A comparison of the old and new tables showed that the use of the new formula resulted in an appreciable lowering of all values in the original table, and a brief table of differences is given, showing the amount by which the new table lowers the former values.

Copies of Circular No. 13 may be obtained without charge by addressing the Engineering Experiment Station, Urbana, Illinois.

Multi-Service Ballast Cars.—Is the title of a circular issued by Enterprise Railway Equipment Company, Chicago. It describes the advantages of this type of car for handling ballast, cinders, coal, ore and other materials.



Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

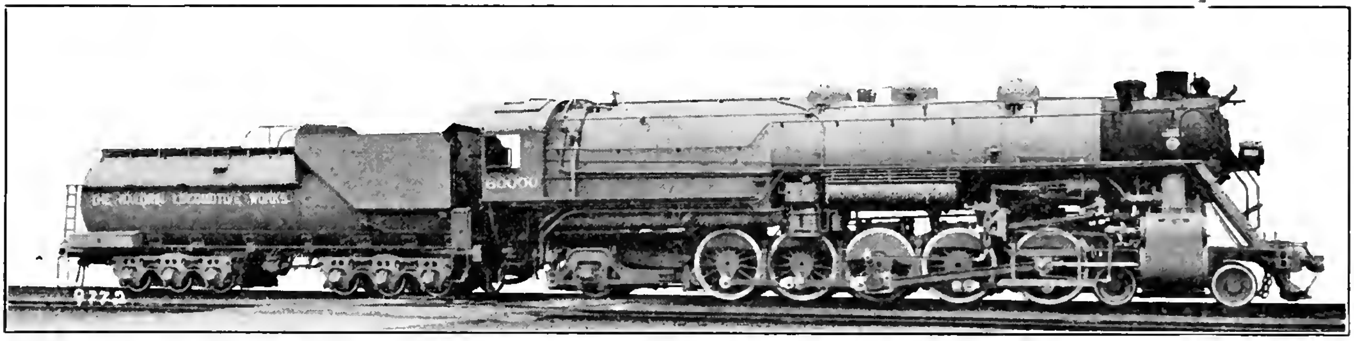
Vol. XL 136 Liberty Street, New York, March, 1927 No. 3

Baldwin Experimental Locomotive No. 60000

A Description and Test Results of the New High-Pressure Three-Cylinder Compound—Water Tube Firebox Feature of Design

During the early part of 1926, the Baldwin Locomotive Works designed and built a new locomotive which embraced many new and novel features in marked departure from the conventional types of locomotives in general use.

The locomotive was exhibited at the Mechanical Convention at Atlantic City in June, 1926, where it attracted considerable of the attention of the railway and other prominent engineers.



Three-Cylinder Experimental Compound Locomotive Built by the Baldwin Locomotive Works

A photographic view of the locomotive and a brief description appeared in the issue of Railway and Locomotive Engineering for July, 1926. Since that time the locomotive was in regular road service on the Pennsylvania Railroad and has been given an extended series of tests at the Altoona testing plant of the Pennsylvania Railroad. The following is a more detailed description of the design and construction of the locomotive as presented by Paul T. Warner of the Baldwin Locomotive Works.

Up to a certain period, development of locomotive design brought with it mainly an increase in weight of individual locomotives, the increase in power beng proportonate to the increase in weight. This increase in power made possible notable economies in railroading. Of late years, however, the demand for still further economies has led locomotive designers to strive to increase the efficiency of the locomotive, and thus give increased power per unit of locomotive weight. Among the means adopted successfully to this end, are the use of superheated steam, various fuel and labor-saving devices, improved boiler design, more efficient steam distribution, and refinements in design and materials for locomotive parts.

At present much thought is being given to the possibility of using higher steam pressures and higher ratios of expansion to give greater cylinder efficiency and consequently greater horse-power per unit of weight.

The great advantage of high pressure steam is that a combination of adequate cylinder force and a high ratio of expansion can be obtained with cylinders of moderate dimensions.

In view of the limits set to steam temperatures by the method of producing the steam and by difficulties of lubrication, locomotive designers must, at least for the present, aim at a steam temperature of approximately 650 degrees F., with a maximum of say 700 degrees, irrespective of the pressure used. Now, if the pressure is increased while the temperature remains constant, the superheater and the heat content per pound of steam fall off as the pressure is increased. For example, a steam temperature of 650 degrees F. gives at 200 pounds per square inch, about 263 degrees superheat and 1340 B. T. U. per pound of steam, and at 350 pounds per square inch about 217 degrees superheat and 1332 B. T. U.

It follows from these figures that if steam of 200 pounds per square inch and of 350 pounds per square inch is expanded to the same exhaust pressure and temperature so that the heat content of the exhaust steam is the same in both cases, there will be no greater thermal efficiency with the higher pressure. To increase the thermal efficiency it is necessary to increase the ratio of expansion so that the heat content at exhaust is reduced.

An increase in the ratio of expansion results in a reduction in the mean effective pressure obtained from a given boiler pressure, and this requires an increase in cylinder dimensions if the same power is to be developed. Now in a large modern locomotive of conventional design, an increase in cylinder dimentions to permit of higher expansion would lead to difficulties in design, and it is advantageous to use higher boiler pressure so that the increase in expansion can be obtained without involving a loss in power or an abnormal increase in cylinder dimensions.

As a means of obtaining the higher expansion necessary to give economy with steam of 350 pounds per square inch, Locomotive 60,000 was designed with three cylinders compounded, the high pressure steam being first admitted to the middle cylinder. After expansion there, the steam passes through the receiver in the cylinder saddle to the two outside cylinders where further expansion takes place.

Steam pressures of 200 to 215 pounds per square inch have been currently used for a number of years, and in the last two or three years a considerable number of locomotives have been built for working steam pressures of 240 and 250 pounds per square inch. This latter is probably about the maximum pressure which can be carried successfully in boilers of the conventional design with fireboxes having flat sides braced by staybolts. The stayed firebox is the weakest point in a locomotive as ordinarily designed, and with pressures carried above 250 pounds per square inch a change in design is necessary to eliminate excessive trouble with staybolt breakage. The decision to use a pressure of 350 pounds per square inch in Locomotive 60,000 led to the adoption of a water tube firebox, and the elimination of all staybolts.

General Description of Locomotive 60,000

The locomotive is of the 4-10-2 type, built for freight service, with driving wheels 63½ inches in diameter, and three cylinders each 27 inches in diameter by 32 inches stroke. The total weight in working order is 457,500 pounds, of which 338,400 are on driving wheels. Full detailed dimensions are given on page 65.

Apart from the modifications necessary to the use of the water-tube firebox and the high pressure, the boiler does not differ in principle from that of the conventional locomotive. The boiler barrel is of the usual firetube type having 206 2¼-inch tubes and a type A superheater carried in 50 5½-inch flues.

The barrel consists of three courses, having plates rspectively $1\frac{5}{16}$, 1⅜ and 1½ inches thick. The third course is sloped on top, increasing the shell diameter from 84 inches at the front end to 94 inches at the back. All circumferential seams are double riveted, and the longitudinal seams are of the so-called "saw-tooth" octuple riveted design, which provides a short caulking distance between the rivets. At the rear, the barrel is closed by a tube sheet, which is riveted to the shell in the usual way. The boiler tubes and flues are welded into this tube sheet.

None of the studs tapped into the boiler passes all the way through the sheets, hence there can be no leaky studs or stays.

The firebox is of the water-tube type, each side wall consisting of 48 tubes 4 inches in diameter connecting a hollow cast steel mud-ring at the bottom to one of the horizontal cylindrical drums at the top. Outside of these side tubes a firebrick shell is built, over which are applied removable cover plates which are covered with magnesia sectional lagging and jacketed. The front and back walls of the firebox are of firebrick, and the opening between the two drums forming the crown of the firebox is also closed with firebrick.

This construction provides a boiler entirely free from staybolts and from flat surfaces requiring staybolts. This feature of the design gives it an important advantage when high steam pressures are to be carried.

The depth of the firebox from the top of the mud-ring to the center line of the drums is 6 feet 6 inches. The total volume, including combustion chamber, reaches the large figure of 683 cubic feet. This gives 8.3 cubic feet of volume for each of the 82.5 square feet of grate area, which is a high relative volume for a modern locomotive, and aids in securing effective and efficient combustion.

The two drums are each 26 inches in diameter and the transverse distance between their centers is 31 inches. They have a total length of 23 feet 6 inches, and extend into the boiler barrel a distance of 5 feet 6 inches ahead of the back tube sheet. The openings in this sheet, through which the drums pass, have flanges 6⅝ inches in depth, to which the drums are double riveted. Each drum is closed, at the rear, by a cover plate which is secured to an internal ring by means of studs, and is fitted with a copper gasket to keep the joint tight. By removing these covers the drums can be entered for purposes of inspection, and the water tubes can be "turbined" during washing-out, to remove any scale. This can be done without removing any of the lower plugs, one of which is placed in the mud-ring opposite each tube end.

The third course in the boiler barrel is sloped on top, and the two upper drums are so located that their forward extensions come in contact with this course and are riveted to it. This acts as a support for the drums, and tends to counteract the cantilever effect of the long overhanging firebox. Furthermore, to balance the effect of the pressure on the covers at the back ends of the drums, three longitudinal stay rods are run from the forward end of each drum to the front tube sheet. These rods are anchored to internal braces which are riveted to the drum. This construction, together with a system of braces connecting the front end of the mud-ring and the boiler barrel, relieves the back tube sheet of any tendency to distortion, due to the firebox overhang and the pressure on the drum heads.

The hollow cast steel mud-ring is connected to each upper drum by 48 tubes each 4 inches in diameter; and there are also four tubes connecting the drums to the back section of the mud-ring. All these tubes are swedged to a diameter of 3 inches at the mud-ring end, where they are rolled and belled, while at the drum end they are rolled, belled and welded. The tube holes in the mud-ring have two depressions rolled into them, into which the tubes lock themselves firmly when being rolled in. Connection between the bottom of the boiler barrel and the front end of the mud-ring is made by two elbow pipes, each 9 inches in diameter, and placed right and left.

The mud-ring, which has a total length of 18 feet 2 inches and a width of 8 feet 5 inches, is cored throughout to permit water circulation. The rectangular outer frame is crossed by a central longitudinal member and also by a transverse member located about six feet back of the front end of the firebox. From this transverse member, which lies at the front end of the grate, five water tubes extend to the upper drums, and serve as supports for the brick arch. That portion of the firebox which is forward of the arch constitutes a combustion chamber and is closed, at the bottom, by a horizontal steel plate, and floored with firebrick. A Y-shaped cinder pocket is applied for cleaning this combustion chamber.

The locomotive is at present arranged for burning coal and is equipped with a Duplex stoker. It can, however, subsequently be changed to burn oil, if necessary.

The dome is placed on the second barrel course, and is connected with the superheater header by an internal dry-pipe. The throttle is placed in the smokebox, between the superheater header and the cylinders; while there is a shut-off valve for the steam supply in the dome.

The three cylinders, with their steam passages and steam chests, are formed in a single grey iron casting. The high-pressure steam chest is placed in the saddle, on the right-hand side, and is connected with the superheater by a single steam pipe. All the piston valves are 14 inches in diameter, that for the high-pressure cylinder being arranged for inside admission, while the valves for the low-pressure (outside) cylinders are arranged for outside admission. The high-pressure exhaust is conveyed to the low-pressure steam chests through passages cored in the cylinder casting; while the exhaust from the low-pressure cylinders passes to the smokebox through outside pipes which terminate in a single exhaust nozzle. A Worthington feed-water heater is applied to this locomotive, and a branch from each exhaust pipe conveys the steam to the heater.

For starting purposes, live steam can be admitted to the low-pressure cylinders through a 1½-inch pipe leading from a manually-controlled valve in the cab. Under all ordinary conditions of operation the locomotive works compound.

The two outside cranks are placed 90 degrees apart, so that there are four even exhausts per revolution, and the inside crank is placed at 135 degrees from each outside crank. The high-pressure piston is connected to the second pair of driving wheels, and the two low-pressure pistons to the third pair. All three piston heads are of the built-up type, with spiders of open hearth cast steel. The main and side rods are of carbon vanadium steel, while the driving axles, main crank pins and piston rods are of open hearth steel, heat treated, oil quenched and hollow bored. The crossheads are of the underhung multiple bearing type, as developed by Mr. J. T. Wallis, Chief of Motive Power of the Pennsylvania Railroad, and now adopted as standard for heavy power by that road. They work in guides having two inwardly projecting horizontal ribs on each side.

Walschaerts valve gear is used, with an independent motion for each cylinder, but all controlled by one type B Ragonnet power reverse gear. The valve for the left-hand cylinder is operated from the left-hand main pin and cross head in the usual way. The right-hand valve receives its lead from the right-hand cross-head, but the link for this cylinder is operated through a transverse shaft, by means of a connection to the left-hand crosshead. The return crank on the right-hand main pin is set to operate the valve for the inside cylinder, and this valve is given lead through a connection with the inside crosshead. The valve motion bearer is a single steel casting supporting practically the entire valve gear.

This locomotive, designed to traverse curves of 17 degrees, has flanged tires on all the wheels. Lateral motion boxes are applied to the first driving axle. The front truck has a swing bolster suspended on heart-shaped links, while the rear truck is of the Delta type, and is so designed that a booster can subsequently be applied if necessary. There is a continuous equalization system on each side of the locomotive, from the leading drivers to the rear truck.

The accessories are all operated by superheated steam at a reduced pressure of 250 pounds, except the feed-water heater and injector, which use saturated steam at 350 pounds pressure.

The tender is carried on two six-wheeled trucks, and is of the Vanderbilt type with capacity for 12,000 gallons of water and 16 tons of coal.

Three-Cylinder Compound 4-10-2 Locomotive

Cylinders

High pressure (1)	27 x 32 ins.
Low pressure (2)	27 x 32 ins.
Valve	Piston 14 ins. diam.

Boiler

Type	Wagon Top.
Diameter	84 ins.
Working pressure	350 lb.
Fuel	Soft coal.
Firebox:	
Type	Water tube.
Length, total	199½ ins.
Width, total	96 ins.
Length of grate	138¼ ins.
Width of grate	86 ins.
Water tubes, number	100 ins.
Water tubes, diam.	4 ins.
Boiler tubes, diam.	5½ ins. and 2¼ ins.
Boiler tubes, number	5½ ins., 50; 2¼ ins., 206.
Boiler tubes, length	23 ft. 0 ins.
Water heating surface:	
Firebox	745 sq. ft.
Tubes	4,420 sq. ft.
Firebrick tubes	27 sq. ft.
Total	5,192 sq. ft.
Superheating surface	1,357 sq. ft.
Grate area	82.5 sq. ft.

Driving Wheels

Diameter, outside	63½ ins.
Diameter, center	56 ins.
Journals, main	12 x 13 ins.
Journals, other	11 x 13 ins.

Engine Truck Wheels

Diameter, front	33 ins.
Journals	7 x 12 ins.
Diameter, back	45½ ins.
Journals	9 x 14 ins.

Wheel Base

Driving	22 ft. 10 ins.
Total engine	45 ft. 2 ins.
Total engine and tender	86 ft. 11¼ ins.

Weight in Working Order

On driving wheels	338,400 lb.
On truck, front	57,500 lb.
On truck, back	61,600 lb.
Total engine	457,500 lb.
Total engine and tender	700,900 lb.

Tender

Wheels, number	Twelve
Wheels, diam.	33 ins.
Journals	6 x 11 ins.
Tank capacity	12,000 gal.
Fuel capacity	16 tons.
Tractive force	82,500 lb.

Discussion of Tests of Locomotive 60,000

By Lawford H. Fry

These extracts deal with all the more important phases of the operation of the locomotive and give also the complete data of the observations made so that a more detailed study may be made by those interested.

The report as quoted presents the observed facts without comment. It is, therefore, supplemented by the present discussion which endeavors to give a certain perspective to the figures, and to establish their relation to similar figures from locomotives of more conventional design.

The locomotive test plant is too well known to require detailed description. On it a locomotive under test is supported on carrying wheels which are controlled by hydraulic friction brakes so that the power developed can be absorbed, while the tractive effort is measured by a dynamometer.

On the test plant it is possible to run a locomotive continuously for an hour or more with perfect uniformity of speed and cut-off. At the same time water and coal measurements, and observations of draft and temperature, can be made with an accuracy unattainable in road tests.

While all test measurements can be made with much more facility and accuracy on the test plant, this is particularly true of indicator diagrams. In the case of road tests, corrections are necessary for acceleration due to grades or change of speed, and it is always possible, by a change in throttle or reverse lever, to produce a card which does not in any way correspond to the speed at which the engine is running. On the test plant such irregularities cannot occur, and the indicator cards are far more reliable than those obtained in road service.

The tests made by the Pennsylvania Railroad on Locomotive 60,000 covered speeds from 80 to 200 revolutions per minute (15 to 37.5 miles per hour), and cut-offs from 50 to 90 per cent in the high-pressure, and 20 to 70 per cent in the low-pressure cylinders. The indicated horsepower developed ranged from 1500 to 4500, at which figure the capacity of the test plant was reached, otherwise a higher power could have been developed.

Maximum power was developed at 200 revolutions per minute with a cut-off of 80 per cent in the high and 50 per cent in the low-pressure cylinders. With these conditions held constant during a test run of one hour's duration, the following results were obtained:

Indicated horse-power	4515
Equivalent evaporation, pounds per hour	83,769
Coal fired, total dry coal, pounds per hour	11,827
Coal fired, dry coal per square foot of grate, pounds per hour	143
Boiler efficiency, per cent	51
Steam per indicated horse-power hour, pounds	14.9
Dry coal per indicated horse-power hour, pounds	2.7
Draw bar pull pounds	35,000

During this test the boiler pressure averaged 344 pounds per square inch, with a temperature of 683 degrees F. or 257 degrees superheat in the branch pipe. The horsepower and equivalent evaporation of this test are both higher than have been reached with any other locomotive on the test plant. They represent approximately the maximum valves likely to be reached by Locomotive 60,000 in regular operation, although as stated elsewhere, they could have been exceeded if the capacity of the test plant had not been reached.

On a repeat test with the same cut-off and speed a similar horse-power was obtained with the same coal rate and a water rate of 15.4 pounds. This gives an average water rate of 15.15 pounds per indicated horsepower hour for a working rate of 4500 horsepower indicated.

The evaporative capacity of the boiler was high, and so far as published records show, is higher than that of any other locomotive boiler tested at Altoona. This is due to the large dimensions of heating surface, grate area and combustion space.

Engine Performance

For all cut-offs between 50/20 (that is 50 per cent in the high and 20 per cent in the low-pressure cylinders) and 80/50 and at all speeds from 15 to 30 miles per hour, 80 to 160 revolutions per minute, the water rate lies between 14.2 and 15.2 pounds per indicated horse-power hour. Even at full gear with a cut-off 90/70, the water rate is only 16.3 pounds at 15 miles per hour, and 16.6 pounds at 22.5 miles per hour.

Examination of the information available from published records shows that the best water rate on record for an American locomotive ranges from 15.5 to 19 pounds, these figures being obtained with 250 pounds per square inch boiler pressure. The usual modern locomotive with a boiler pressure of 200 pounds per square inch and possible full stroke cut-off will usually be found to have a water rate ranging from 17 to 27 pounds per indicated horsepower hour.

It is evident that in Locomotive 60,000 the combination of high pressure and high expansion gives a high degree of engine efficiency.

Owing to the high ratio of expansion obtained in the compound cylinders of Locomotive 60,000, the pressures at the end of expansion are less than would usually be obtained in single expansion cylinders using steam of lower initial pressure. This is a factor in increasing the cylinder efficiency. At the end of expansion the steam is exhausted and loses pressure without doing useful work. This represents a loss which can be reduced by a high ratio of expansion which produces low pressures, at the end of expansion.

The proportion of power developed respectively by the high and by the low-pressure cylinders varies with the speed and cut-off. At 200 revolutions per minute and a cut-off of 80/50 when developing 4500 horsepower as above, the high-pressure cylinder delivers 1080 horsepower or 24 per cent of the total, leaving an average of 38 per cent for each of the low-pressure cylinders. That is, at this speed and cut-off, the high-pressure cylinder does about one-third less work than each of the low-pressure cylinders. If the speed of 200 revolutions per minute be maintained and the cut-off shortened of 60/30 the indicated horsepower drops to 2880, of which only 145 horsepower, or 5 per cent, is contributed by the high-pressure cylinder. This combination of cut-off and speed does not represent conditions likely to be met in actual service, as the power developed is only slightly over one-half that of which the engine is capable.

These tests are interesting in showing that a drawbar pull less than the maximum capacity of Locomotive 60,000, can in many cases be obtained more economically by throttling than by shortening the cut-off. This is contrary to the generally accepted practice with ordinary single expansion locomotives, but for Locomotive 60,000 is borne out by experience in road tests. In actual service it is usually better to use the throttle rather than the reverse lever for minor reductions in tractive effort.

Extracts from Pennsylvania Railroad Test Department Report

Tests have been made of a Baldwin three-cylinder compound freight locomotive which has a number of unusual features. It is of the 4-10-2 type with a working boiler pressure of 350 pounds per square inch, and is fitted with a Worthington feedwater heater, Duplex stoker and type A superheater. The boiler has a water-tube firebox, and forward of the firebox is of the usual firetube type with a 50-element superheater.

The cylinders, which are all of the same diameter and stroke, 27 inches by 32 inches, are compounded. The middle cylinder is the high-pressure. Its exhaust passes into a receiver in the cylinder casting which is connected with the steam chests of the two low-pressure cylinders.

All of the tests were made with run-of-mine bituminous coal from the Keystone Coal and Coke Company's Crows Nest Mine at Hempfield, Westmoreland County, Pennsylvania. This coal is used at the test plant as standard freight locomotive coal.

Average analysis of the coal was as follows:

Proximate Analysis

	Per Cent
Fixed carbon	57.92
Volatile matter	31.73
Moisture, combined	0.74
Ash	9.61
	100.00

Ultimate Analysis

	Per Cent
Carbon	74.21
Hydrogen	5.20
Nitrogen	1.37
Oxygen	7.11
Sulphur	1.73
Ash	10.38
	100.00
Sulphur determined separately	1.84
Total moisture	2.43
Calorific value B. T. U. per pound dry coal	13.704

Locomotive 60,000 was operated on the test plant without change in the counterbalancing and speeds up to 200 revolutions per minute (37.5 miles per hour) were attained without excessive vibration. Two-cylinder locomotive must be specially counterbalanced for the test plant to be able to operate satisfactorily at speeds above 160 revolutions per minute.

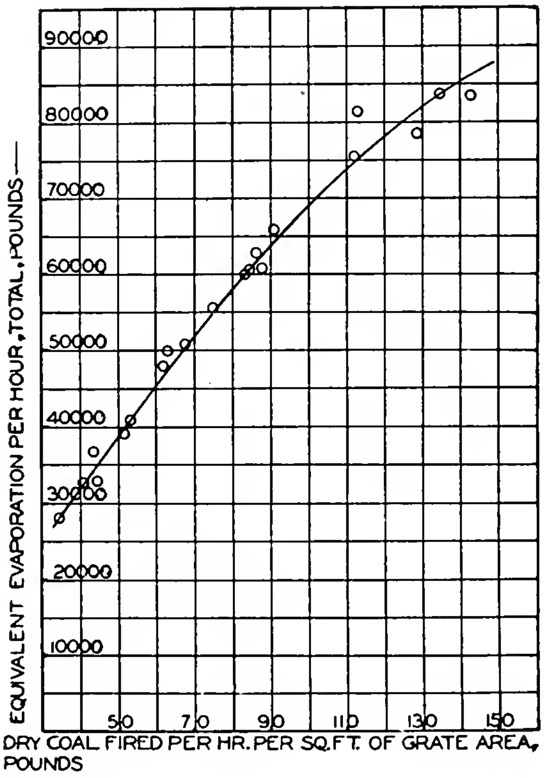


Fig. 1. Relation Between Equivalent Evaporation Per Hour and Rate of Firing

Boiler Performance

In the following discussion of boiler performance, a distinction is made between the performance of the boiler proper and the combined performance of boiler and feedwater heater. The items "equivalent evaporation" and "boiler efficiency" are based on the heat transferred in the boiler proper. In the items "most steam per hour" and "superheated steam per hour" the work of boiler and feedwater heater cannot be separated, and therefore these items are not directly comparable with similar items in reports of tests of boilers not equipped with feedwater heaters.

Locomotive 60,000 has a grate area of 82.5 square feet. The maximum rate of firing reached in the test was 150 pounds of coal as fired per square foot of grate per hour, which is equal to 12,388 pounds of coal per hour.

No attempt was made to work the locomotive at a higher rate, because at 150 pounds per square foot per hour the evaporation was very large and the power output of the locomotive had reached the maximum capacity of the test plant.

In all tests the values of the boiler pressure averaged throughout each test ranged between 343 and 350 pounds per square inch.

The maximum evaporative capacity of Locomotive 60,000 was 69,695 pounds of moist steam per hour. This includes the exhaust steam reclaimed by the feedwater heater. The corresponding maximum equivalent evaporation was 84,184 pounds per hour. At this rate the steam pressure and temperature were well maintained, and as the rate of firing was only 135 pounds of dry coal per hour, this evaporation could undoubtedly have been increased had not the locomotive already reached the maximum capacity of the test plant.

The total equivalent evaporation is plotted (Fig. 1) in relation to the rate of firing per square foot of grate per hour, while the equivalent evaporation per pound of dry coal is plotted against the rate of firing per square foot of grate per hour in (Fig. 2).

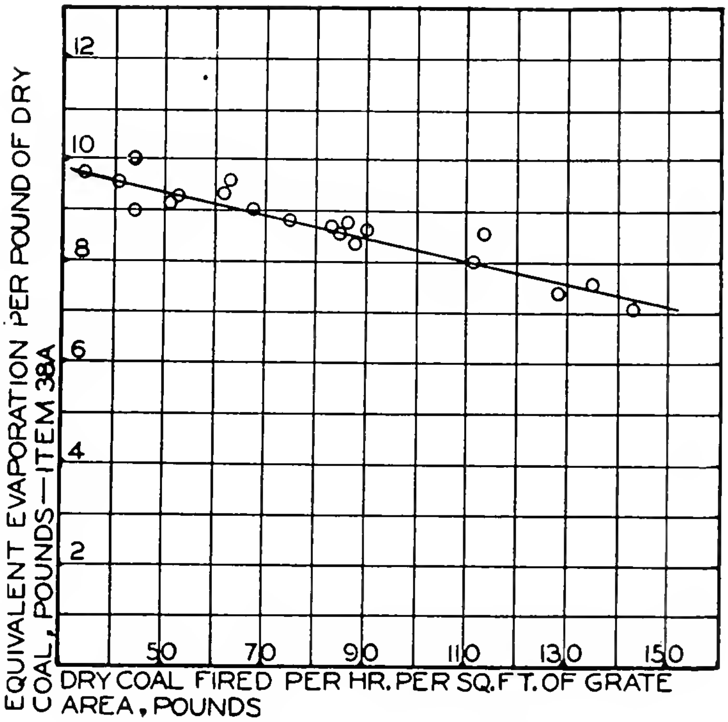


Fig. 2 Relation Between Equivalent Evaporation Per Pound of Dry Coal and Rate of Firing

The boiler efficiency in per cent is plotted in (Fig. 3) against the rate of firing. The efficiency of heat absorption is practically constant at about 82 per cent for all rates of firing; the decrease in boiler effciency, as the rate of firing is increased, being due to a decrease in the efficiency of combustion.

Locomotive 60,000 was equipped with a Worthington heater having a capacity of 60,000 pounds per hour which is large enough to supply all of the feedwater required in the heaviest tests. The rise in feedwater temperature in the heater ranged from 127 to 169 degrees F. and the heat saving from 7.4 to 10.4 per cent.

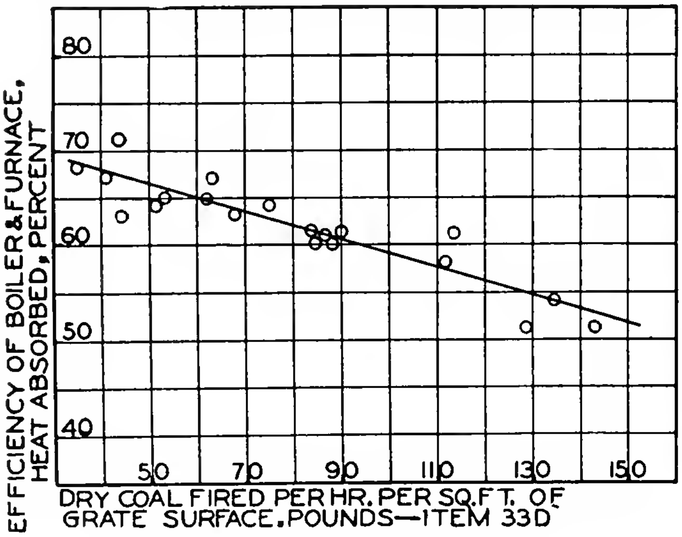
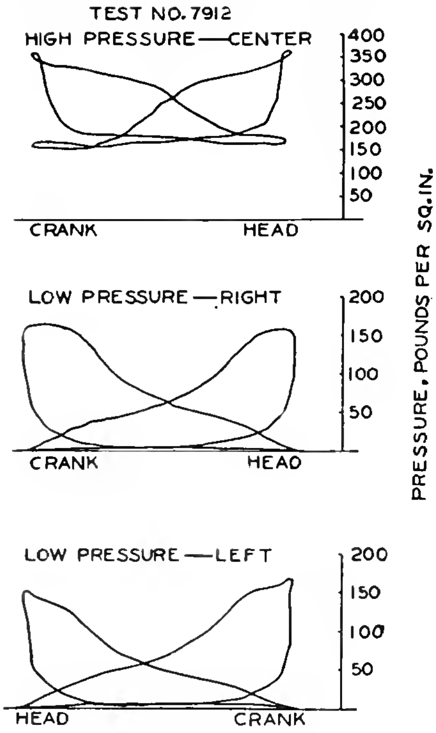
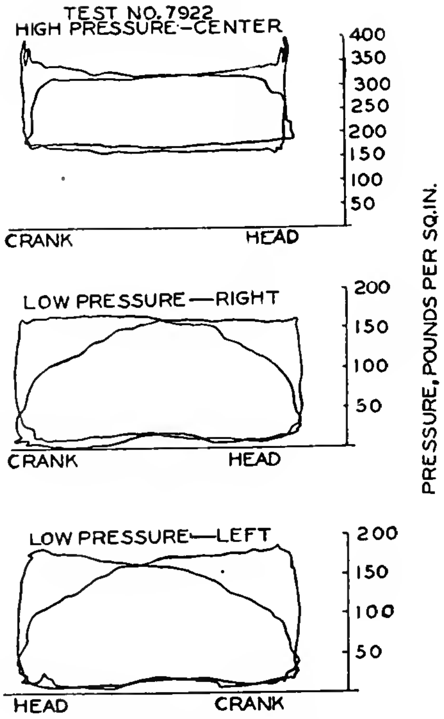


Fig. 3. Relation Between Boiler Efficiency and Rate of Firing



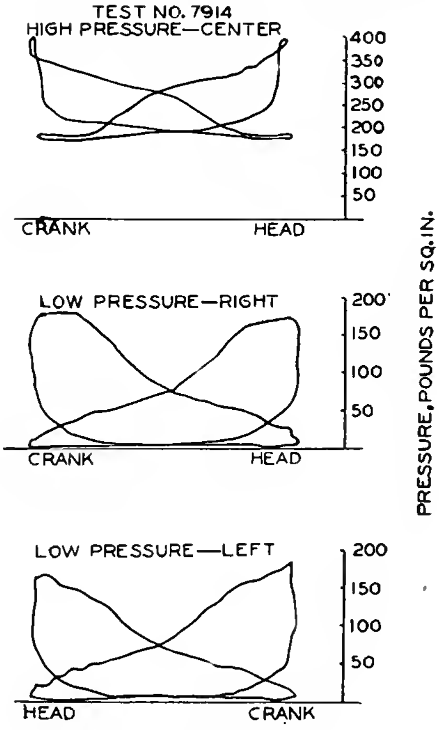
R. P. M., 80; Cut-off, 50/20; Throttle, full; I. H. P., 1471; Speed, M. P. H., 15.0

Fig. 5



R. P. M., 80; Cut-off, 90/70; Throttle, full; I. H. P., 3034; Speed, M. P. H., 15 0

Fig. 6



R P. M., 120; Cut-off, 60/30; Throttle, full; I. H. P., 2333; Speed, M. P. H., 22.5

Fig. 7

The temperature of the water delivered by the heater was from 30 to 13 degrees below the temperature corresponding to the pressure of the exhaust steam at the heater.

Engine Performance

The maximum indicated horsepower developed by Locomotive 60,000 was 4515. This was obtained in with a cut-off of 80 per cent in the high, and 50 per cent in the low-pressure cylinders, the speed being 200 revolutions per minute or 37.5 miles per hour. This is the greatest indicated horse-power ever developed on the test plant.

A curve showing the average water rate at all speeds and cut-offs is plotted (Fig. 4) in relation to the indicated horsepower. This curve is flatter than that obtained with any single expansion locomotive. For all cut-offs between 50/20 and 80/50 per cent, and all speeds from 80 to 160 revolutions per minute, the water rate lies between 14.2 and 15.2 pounds per indicated horsepower hour. For a cut-off of 90 per cent in the high and 70 per cent in the low-pressure cylinders, the water rate is 16.3 pounds at 80 revolutions per minute and 16.6 pounds at 120 revolutions per minute.

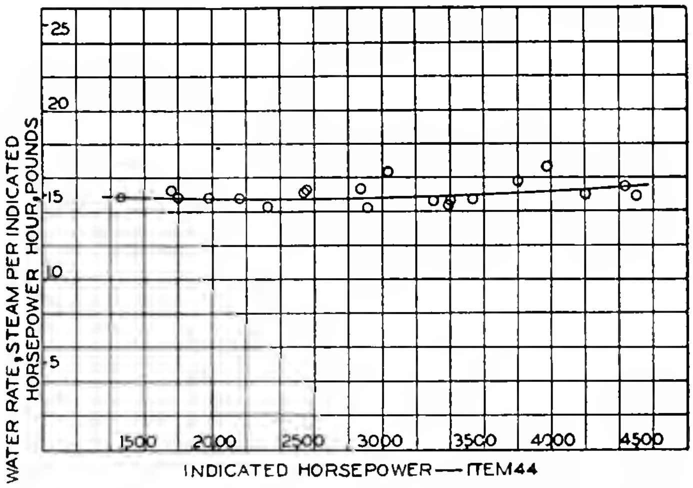
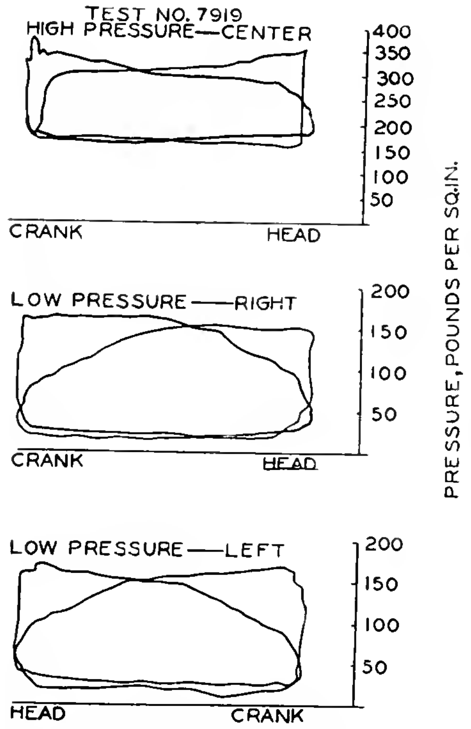


Fig. 4. Relation Between Water Rate and Indicated Horsepower

Locomotive 60,000 has its best water rates at speeds of 120 and 160 revolutions per minute, or 22.5 and 30 miles per hour. In a test with cut-offs of 70 per cent in the high and 40 per cent in the low-pressure cylinders, and at a speed of 120 revolutions per minute, the water rate was 14.2 pounds per indicated horsepower, which is lower than that of any other locomotive ever tested on the plant.

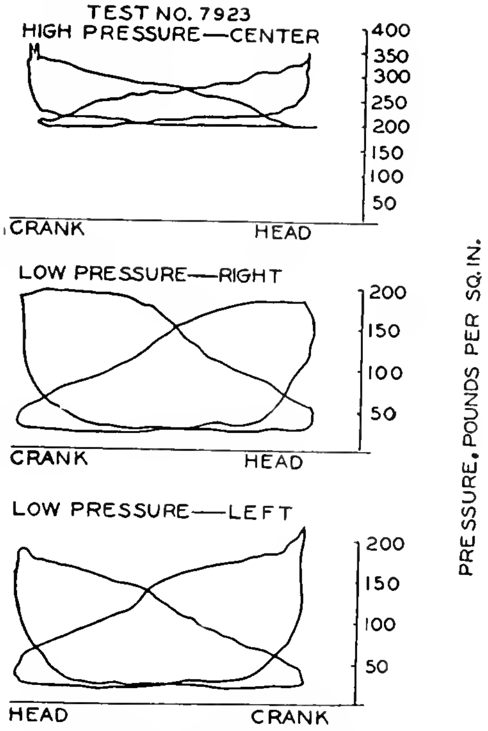
Figs. 5 to 9 show typical indicator cards at representative speeds and cut-offs, while Figs. 10 and 11 show sets of combined indicator cards for cut-offs of 50/20 and 70/40, and 80 and 200 revolutions per minute. These combined cards have been prepared to show the relation of cylinder clearance to total volume, and the action of the steam between the high and low-pressure cylinders was practically the same as is usually observed in locomotives using lower boiler pressure.

WORKS



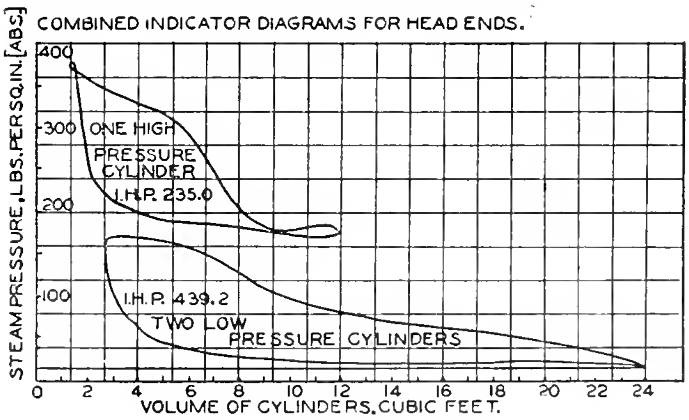
R. P. M., 120; Cut-off, 90/70; Throttle, full; I. H. P., 3978; Speed, M. P. H., 22.5

Fig. 8



R. P. M., 200; Cut-off, 80/50; Throttle, full; I. H. P., 4515; Speed, M. P. H., 37.6

Fig. 9



TEST No. 7912

Fig. 10

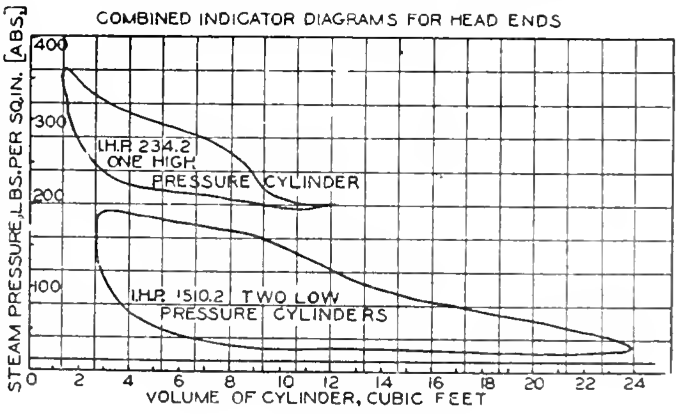
Speed, rev. per min., 80; miles per hour, 15.0
Cut-off, high-press., 50; low press., 20
Throttle opening, full

Steam in branch pipe	Press., 339; temp., 568
" " receiver, right side	" , 160; " , 417
" " " , left "	" , 159; " , 392
" " exhaust pipe, right side	" , 2.1; " , 220
Indicated horse-power, total	1471
Steam per I. H. P. per hour, pounds	14.9

At a speed of 80 revolutions per minute and at all cut-offs the high-pressure cylinder developed slightly more work than is developed in each of the low-pressure cylinders, while at 120 revolutions per minute the position is reversed and the high-pressure develops slightly less work than each low-pressure cylinder. As the speed is increased the percentage of work developed in the high-pressure cylinder falls off rapidly. The difference is greater with short cut-offs than with long. At a speed of 200 revolutions per minute and a cut-off of 60/30 per cent, the work in the high-pressure cylinder was about one-tenth of that of one of the low-pressure cylinders. Nevertheless, under these conditions, the water rate was still good, being 15.3 pounds per indicated horse-power hour.

The machine efficiency of Locomotive 60,000 is plotted in Fig. 12 in relation to the draw-bar pull. It appears to vary with the draw-bar pull and to be independent of the speed. There is no noticeable difference between the machine efficiency of Locomotive 60,000 and that of other modern locomotives which has been tested on the Altoona test plant.

The coal rate of Locomotive 60,000 is approximately 2½ pounds in the middle of the working range, increasing somewhat at the lower rates and at rates above 2000 draw-bar horse-power. A rate of 3¼ pounds of dry coal per draw-bar horse-power hour was reached at the maximum output of about 3600 draw-bar horse-power.



TEST No. 7925

Fig. 11

Speed, rev. per min., 200; miles per hour, 37.6
Cut-off, high-press., 70; low-press., 40
Throttle opening, full

Steam in branch pipe	Press., 321; temp., 674
" " receiver, right side	" , 197; " , 618
" " " , left "	" , 196; " , 585
" " exhaust pipe, right side	" , 14.2; " , 317
Indicated horse-power, total	3804
Steam per I. H. P. per hour, pounds	15.8

The efficiency for Locomotive 60,000 varies between 7.8 per cent for a cut-off of 80/50 per cent at 80 revolutions per minute, and 5.6 per cent for the same cut-off at 200 revolutions per minute.

Curves are given in Fig. 13 showing the draw-bar pull at various speeds and cut-offs.

Locomotive 60,000, hauling any train within its capacity, the speed can be increased from 15 miles per hour to 25 miles per hour with practically no change in coal rate.

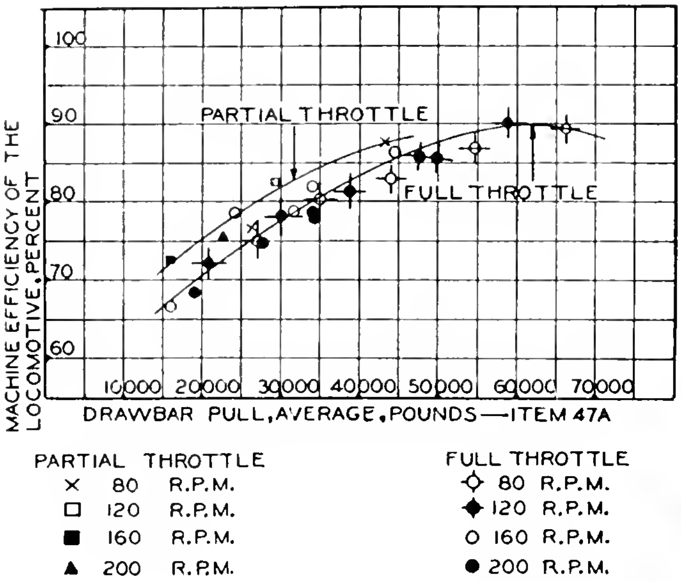


Fig. 12. Relation Between Machine Efficiency and Draw-Bar Pull

Throttling Tests

Five tests were made to determine the effect on the economy of the locomotive of a reduction of the pressure in the branch pipe by throttling. The method of making these tests was to throttle the steam at the steam chest to 200 or 250 pounds, and to lengthen the cut-off until the draw-bar pull was the same as in a previous test at the same speed with full throttle. The results of these five tests are shown in the table on page 71 in comparison with the corresponding full throttle tests. The following

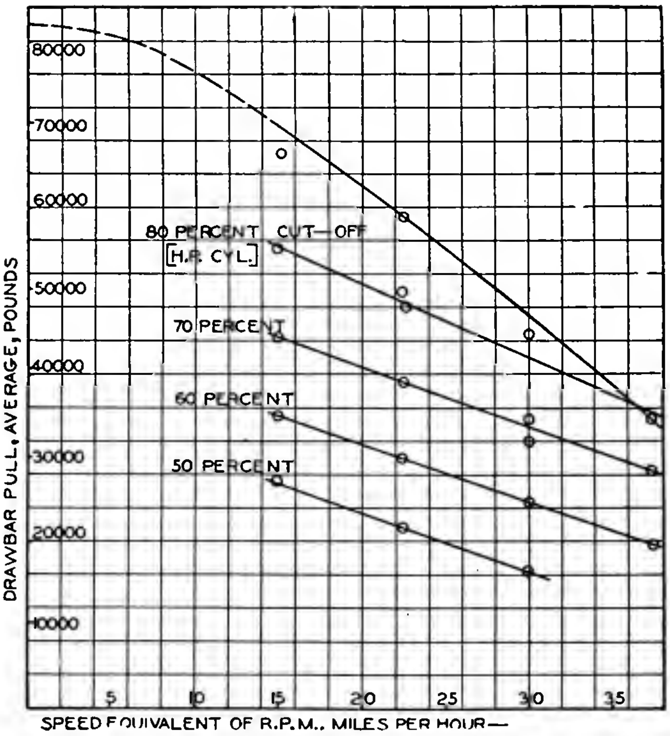


Fig. 13. Relation Between Draw-Bar Pull and Speed for Various Cut-Offs

Engine Performance

Pressures from Indicator Diagrams, Averages, Pounds per Square Inch

Test No.	Test Designation, R. P. M., Cut-off, Throttle	Steam Chest Pressure		Initial Pressure		Pressure at Cut-off		Least Back Pressure		Total Indicated Horse-power	Dry Coal per I. H. P. per Hour, Lb.	Steam per I. H. P. per Hour, Lb.
		High Pressure Cylinder	Two Low Pressure Cylinders	High Pressure Cylinders	Two Low Pressure Cylinders	High Pressure Cylinder	Two Low Pressure Cylinders	High Pressure Cylinder	Two Low Pressure Cylinders			
1	1a	43b	43b	43c	43c	43d	43d	43e	43e	44	44	46
7912	80-50/20-F	335	160	348	158	248	114	159	1	1471	1.8	14.9
7910	80-60/30-F	335	160	347	165	263	123	164	2	1763	1.9	15.2
7911	80-70/40-F	335	170	351	173	273	127	172	2	2164	1.9	14.8
7906	80-80/50-F	325	170	353	175	282	130	167	5	2560	1.9	15.2
7922	80-90/70-F	330	165	357	165	306	138	164	6	3034	2.4	16.3
7917	120-50/20-F	340	160	354	157	213	98	161	2	1807	2.0	14.7
7914	120-60/30-F	340	175	361	171	235	118	174	4	2333	1.9	14.3
7913	120-70/40-F	335	180	361	178	239	126	180	5	2914	1.9	14.2
7907	120-80/50-F	320	170	355	176	247	128	175	10	3411	2.0	14.6
7908	120-80/50-F	325	170	351	176	251	133	175	8	3544	2.1	14.7
7919	120-90/70-F	315	165	347	160	273	128	163	19	3978	2.3	16.6
7918	160-50/20-F	345	175	347	169	214	99	164	2	1986	1.8	14.8
7915	160-60/30-F	340	185	348	178	219	110	181	4	2545	2.0	15.1
7916	160-70/40-F	335	190	355	190	220	121	184	9	3395	2.0	14.4
7926	160-70/40-F	330	190	348	183	219	126	182	13	3304	2.1	14.6
7909	160-80/50-F	320	180	343	179	234	129	179	13	4207	2.5	15.0
7924	200-60/30-F	330	200	335	191	218	121	163	10	2880	2.1	15.3
7925	200-70/40-F	320	200	340	194	223	124	194	14	3804	2.4	15.8
7923	200-80/50-F	310	185	333	186	221	131	188	19	4515	2.6	14.9
7927	200-80/50-F	310	185	338	187	210	122	181	20	4450	2.5	15.4
	PARTIAL THROTTLE											
7928	80-70/40-P	245	100	290	98	152	72	101	3	1400	2.1	16.2
7929	80-90/70-P	250	95	294	94	192	77	99	5	2018	2.1	16.8
7920	120-80/50-P	222	95	262	97	143	69	97	3	2188	1.9	15.0
7921	160-70/40-P	185	105	232	104	112	59	100	3	1781	2.0	15.3
7930	200-80/50-P	195	100	239	94	123	60	103	9	2739	2.1	15.4

table shows a comparison of the principal items on a percentage basis:

THROTTLE TESTS

Approximate draw-bar pull	27,000	44,000	30,000	16,000	20,000
Test Conditions:					
Approximate speed	15	15	22.5	30	37.6
Increase in water rate per indicated horse-power hour when throttling, Item 46, per cent	8.7	13.5	4.7	3.3	0.6
Increase in machine efficiency when throttling, Item 51, per cent	2.1	5.3	6.2	9.1	11.2
Decrease in coal rate per draw-bar horse-power hour, when throttling, Item 48a, per cent	....	...	0.0	....	12.50
Increase in coal rate per draw-bar horse-power hour, when throttling Item 48a, per cent	7.7	4.2	0.0	3.6	.....

The coal rate per indicated horse-power hour shown by these tests, indicates that throttling so as to reduce the branch pipe pressure by 100 to 150 pounds per square inch has little effect on the overall efficiency of the locomotive. In one test the coal rate is not affected by throttling, in one it is increased and in two reduced. Theoretical considerations lead to the expectation that the water rate would be increased, and this is shown in all five tests. Also, in all five tests the machine efficiency was increased.

Summary of Results of Tests

The following tables are selected as representative from a number of similar tables which give a summary of the results of the tests of locomotive No. 60,000. The various columns in these tables are designated by numbers, which in all cases correspond with those used in the official report of the Pennsylvania Railroad.

GENERAL LOCOMOTIVE PERFORMANCE

TEST No.	TEST DESIGNATION, R. P. M., CUT-OFF, THROTTLE	Drawbar Horse-power	Drawbar Pull, Average, Lb.	Dry Coal per Drawbar H. P. per Hour, Lb.	Steam per Drawbar H. P. per Hour, Lb.	Tractive Force Based on M. E. P., Pounds	Locomotive Friction Expressed as Pull at Drawbar, Pounds	Machine Efficiency of Locomotive, Per Cent	Efficiency of Locomotive, Per Cent
1	1a	47	47a	48a	49	49b	50a	51	52
7912	80–50/20–F	1099	27428	2.6	20.4	36702	9281	74.7	7.0
7910	80–60/30–F	1411	35216	2.4	19.3	43989	8783	80.0	7.6
7911	80–70/40–F	1789	44625	2.4	18.2	53992	9356	82.7	7.7
7906	80–80/50–F	2216	55286	2.4	17.8	63872	8583	86.6	7.8
7922	80–90/70–F	2706	66670	2.7	18.6	74764	8083	89.2	6.9
7917	120–50/20–F	1295	21544	2.8	21.0	30057	8516	71.7	6.5
7914	120–60/30–F	1807	30055	2.4	18.8	38806	8749	77.5	7.4
7913	120–70/40–F....................	2365	39342	2.4	17.8	48470	9132	81.2	7.6
7907	120–80/50–F	2914	48143	2.5	17.3	56361	8212	85.4	7.4
7908	120–80/50–F	3020	50239	2.5	17.5	58949	8716	85.2	7.4
7919	120–90/70–F	3577	59451	2.6	18.8	66113	6664	89.9	7.1
7918	160–50/20–F	1308	16320	2.8	22.9	24775	8458	65.9	6.6
7915	160–60/30–F	1990	24820	2.6	19.7	31749	6924	78.2	7.0
7916	160–70/40–F	2766	34511	2.5	18.0	42353	7847	81.5	7.2
7926	160–70/40–F	2581	32197	2.7	19.0	41218	9019	78.1	6.9
7909	160–80/50–F	3604	44961	3.0	17.7	52483	7522	85.7	6.1
7924	200–60/30–F	1954	19502	3.2	23.1	28743	9242	67.8	5.8
7925	200–70/40–F	2829	28235	3.3	21.5	37964	9731	74.4	5.6
7923	200–80/50–F	3506	34991	3.4	19.6	45060	10070	77.7	5.6
7927	200–80/50–F	3479	34722	3.2	20.0	44411	9691	78.2	5.8
					PARTIAL THROTTLE				
7928	80–70/40–P	1068	26655	2.8	21.8	34930	8283	76.3	6.7
7929	80–90/70–P	1758	43860	2.5	19.8	50349	6487	87.1	7.3
7920	120–80/50–P	1801	29957	2.4	18.6	36394	6437	82.3	7.9
7921	160–70/40–P	1281	15975	2.9	21.8	22218	6238	71.9	6.4
7930	200–80/50–P	2066	20618	2.8	20.7	27335	6717	75.4	6.6

THROTTLING TESTS

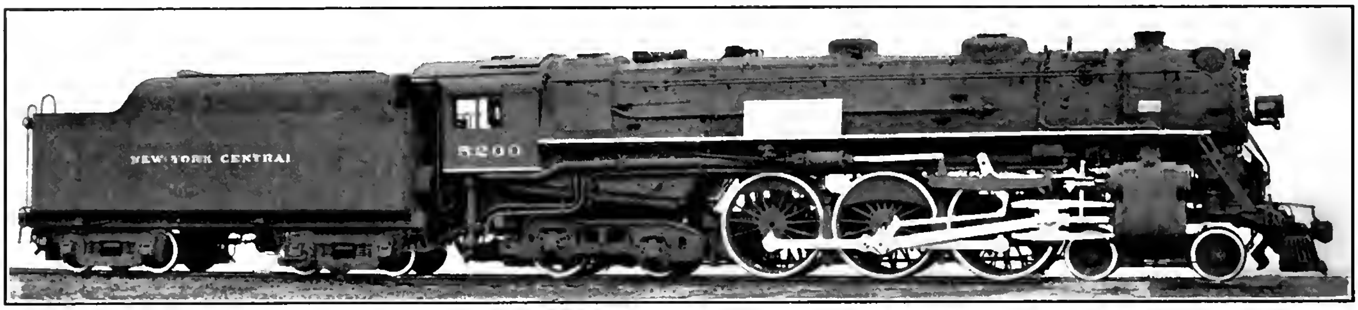
		Opening of Throttle Valve, Full or Partial									
		Part	Full	Part	Full	Part	Full	Part	Full	Part	Full
Test No. (1)		7928	7912	7929	7911	7920	7914	7921	7918	7930	7924
Designation (1a)	Speed	80	80	80	80	120	120	160	160	200	200
	H. P. Cut-off	70	50	90	70	80	60	70	50	80	60
	L. P. Cut-off	40	20	70	40	50	30	40	20	50	30
	Throttle	P	F	P	F	P	F	P	F	P	F
Boiler Press., lb. per sq. in. (26)		346	347	349	349	349	349	350	349	348	346
Branch Pipe Press., lb. (26a)		253	339	254	337	217	335	192	339	202	327
Exhaust Pipe Press., lb. (26b)		1.7	2.1	4.6	4.0	4.8	3.0	3.2	3.5	7.8	8.6
Steam Temperature in Branch Pipe (24)		550	568	607	600	599	615	565	613	614	651
Steam Temperature in Exhaust Pipe (24a) ...		218	220	228	228	228	226	223	224	251	286
Superheat of Exhaust Steam		2	4	3	6	3	7	4	2	18	50
Indicated Horse-power (44)		1400	1471	2018	2164	2188	2333	1781	1986	2739	2880
Steam per I. H. P.-Hr. (46)		16.2	14.9	16.8	14.8	15.0	14.3	15.3	14.8	15.4	15.3
Dry Coal per I. H. P.-Hr. (45a)		2.1	1.8	2.1	1.9	1.9	1.9	2.0	1.8	2.1	2.1
Drawbar Pull (47a)		26655	27428	43860	44625	29957	30055	15975	16320	20618	19502
Drawbar Horse-power (47)		1068	1099	1758	1789	1801	1807	1281	1308	2066	1954
Steam per D. H. P.-Hr. (49)		21.8	20.4	19.8	18.2	18.6	18.8	21.8	22.9	20.7	23.1
Dry Coal per D. H. P.-Hr. (48a)		2.8	2.6	2.5	2.4	2.4	2.4	2.9	2.8	2.8	3.2
Machine Efficiency, Per Cent (51)		76.3	74.7	87.1	82.7	82.3	77.5	71.9	65.9	75.4	67.8
Efficiency of Locomotive, Per Cent (52)		6.7	7.0	7.3	7.7	7.9	7.4	6.4	6.6	6.6	5.8

New Hudson Type Locomotive of the New York Central

First of 4-6-4 Wheel Arrangement Is for Heavy Fast Passenger Service

On February 14 a new locomotive of the 4-6-4 wheel arrangement was delivered to the New York Central by the builders, the American Locomotive Company. As it was the first of its class it was formally christened the "Hudson" type. The locomotive is intended to be used in main line high-speed passenger service on trains such as the Twentieth Century Limited, the Empire State Express, the Southwestern Limited, etc. The use of the four-wheel trailer permits the development of a greater increase in boiler capacity and power output, than is possible with the Pacific or 4-6-2 wheel arrangement.

The locomotive develops a maximum rated tractive force of 53,500 lb., including 10,900 lb. which is supplied by the locomotive booster. The cylinders are 25 x 28 inches and the boiler pressure is 225 lb. per sq. in. The driving wheels are 79 in. in diameter. The weight on drivers is 182,000 lb., or slightly more than 60,000 lb., per pair. The total weight of the engine is 343,000 lb., of which 63,500 lb. is on the front truck and 97,000 lb. is on the four-wheel trailer truck.



New "Hudson" or 4-6-2 Type Locomotive Built by the American Locomotive Company

The "Hudson Type" locomotive is 88 ft. in length over all and with its tender weighs 552,000 lb., as against an overall length of 76 ft. 2½ in. and a weight of 464,000 lb. for the Pacific or 4-6-2 design of the New York Central.

The boiler is of maximum capacity to give sustained power without forcing. This high capacity boiler is made possible by the use of the four-wheel trailer truck with increased firebox size, the Type E super-heater and the increase in heating surfaces. The firebox is 130 in. by 90¼ in. with a grate area of 81½ sq. ft., and is fitted with Monroe Steel Company's grate bars which accounted for a substantial reduction in weight. The ashpan is the Commonwealth Steel Company's cast steel type. The Duplex stoker is employed. The Type E super-heater is used with 1,965 sq. ft. of heating surface. The total evaporative heating surface is 4,491 sq. ft., so that the combined evaporative and super-heater surfaces is 6,456 sq. ft.

The engineering in the design of the locomotive is a distinct achievement in a number of features which were worked out co-operatively by the engineering departments of both the American Locomotive Company and the railroad. A feature strikingly apparent is that the factor of appearance has not been neglected. The locomotive may be described as of "stream line."

Particular care was given to the arrangement of piping so as to secure the best appearance possible. Sand pipes and traps are located under the jacket. All other pipes are located in as inconspicuous a place as possible and secured with Economy pipe clamps. The piping on left hand side of boiler is so arranged that the reservoirs, reservoir brackets and the pipe secured to same can be removed as a unit. Stress was laid on the importance of combining two or more brackets into a unit so as to reduce the number of details and, at the same time, reduce the number of studs into boiler. Note, for instance, combined reservoir bracket, pipe clamp and booster throttle valve bracket on left hand side of engine, force feed lubricator and feed water condensate trap support on right hand side, and the reverse cylinder support and distributing valve bracket also on right hand side.

Air pumps have been located back of the front bumper bracket on a number of locomotives, but this is, perhaps, the first time that the feed pump has been located in a similar position. Locating the pump in this manner permits of a free flow of water from the tank to the pump and a short delivery to the heater drum. Attention should be called to the location of the heater drum which is partially concealed in a depression in smokebox and the pipes connecting the pump to the drum are carried through a conduit welded in the smokebox, all of which is a distinct improvement in appearance over the usual application.

The Elesco feedwater heater is located below the top of the smokebox shell, which greatly improves the appearance of the locomotive. The heater is supported on a shelf welded into the top of the smokebox just back of the front end door ring. With the heater in place, the opening above the shelf is closed with plates so that only the ends of the heater are exposed beyond the curve of the smokebox shell. The feedwater heater pipes and connections pass down through the smokebox and are welded to the heater shelf at the top and to the smokebox sheets at the bottom.

The locomotive is equipped with the American Multiple throttle a description of which appeared in the January, 1927, issue of RAILWAY AND LOCOMOTIVE ENGINEERING. The disc throttle valves are located in the super-heater header casting. A removable cover is provided directly over the super-heater header, in back of the stack on the smokebox.

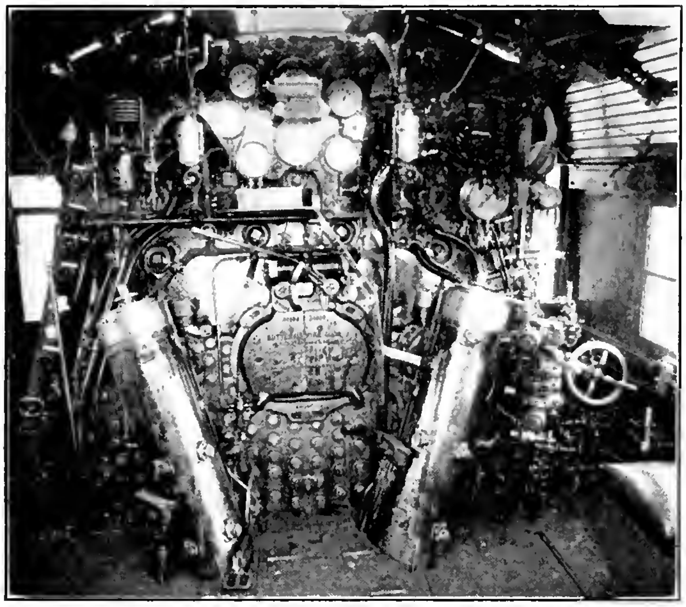
The cylinders are of cast steel with inside exhaust passages.

The Commonwealth four-wheel Delta type trailing truck with back wheel arranged for booster was applied. The design was worked out in combination with standard inside cradle, giving maximum ash pan capacity and, at the same time, permitting the draft of the engine to come through the cradle in the regular manner, rather than through the truck frame, as would be the case with an articulated truck. The front wheels of the trailer truck are 36 in. in diameter while the rear wheels which carry the type C-2 booster are 51 in. in diameter.

Other features of the machinery details include the American Locomotive Company's design of main driving boxes which are fitted with supplementary bearings on both sides below the center line of the axle and are held in position against shoulders on the lower edges of the crown brass by wedges. The engine truck box cellars are by Alco "Quicpac" type which are readily accessible from the inside of the engine and can be packed without the necessity of dropping the cellars.

A Walschaert valve gear arranged for long travel and a Precision reverse gear controls the steam distribution.

Other special equipment include the General Railway Signal automatic train control, Nathan automatic force feed lubricator, Graham-White sanders, Pierce bell ringer; Franklin Butterfly firedoor, adjustable wedges, locomotive booster, and radial buffer.



Cab Interior of the New "Hudson" Type Locomotive

Care was also exercised in the arrangement of the cab fittings. All steam pipes possible have been kept outside of the cab, cab turret being located under the cab turret casing immediately ahead of the cab, from which the pipes extend down through turret casing and thence to their respective destinations. Steam valves in the turret are operated by extension handles, extending back into the cab, all of which are identified by name plates riveted to the extension guide which is a part of the main instrument board. All gauges in the cab, with the exception of the air and back pressure gauges, are assembled on one common gauge board readily visible to the engine crew. This arrangement of cab fitting was the subject of much favorable criticism on the part of the railroad company's inspection committee.

Everything has been done in locating fittings to make same as convenient as possible for the engine crew.

The tender is of ample capacity for the maintenance of maximum power over long locomotive runs without stops, as it will carry 10,000 gal. of water and 18 tons of coal.

The new locomotive commenced active duty in freight train service, for "breaking in," after which it will be used first on short passenger runs and next doubtless will haul the Century and other heavy Pullman trains throughout the New York Central System.

As a result of the co-operation of the builder's entire organization the locomotive was built in an unusually short time. The boiler was received on the erecting floor on January 28, the main frames on February 1, and the cylinders on February 2. The locomotive was steamed, weighed, and given a trial run on February 8, and completely finished and painted on February 9. No effort, however, was spared to provide a high standard of workmanship throughout.

The table gives the principal weights, proportions and dimensions of the new "Hudson Type."

Table of Dimensions, Weights and Proportions of the Hudson Type Locomotive

Railroad	New York Central
Type of locomotive	4-6-4
Service	Passenger
Cylinders, diameter and stroke	25 in. by 28 in.
Valve gear, type	Walschaert
Valves, piston type, size	14 in.
Maximum travel	9 in.
Steam lap	1$\frac{5}{16}$ in.
Exhaust clearance	¼ in.
Lead	⅛ in.
Cut-off in full gear, per cent	86
Weights in working order:	
On drivers	182,000 lb.
On front truck	63,500 lb.
On trailing truck, front wheels	44,000 lb.
On trailing truck, rear wheels	53,500 lb.
Total engine	343,000 lb.
Tender	209,000 lb.
Wheel bases:	
Driving	14 ft. 0 in.
Rigid	14 ft. 0 in.
Total engine	40 ft. 4 in.
Total engine and tender	76 ft. 1½ in.
Wheels, diameter outside tires:	
Driving	79 in.
Front truck	36 in.
Trailing truck, front wheels	36 in.
Trailing truck, rear wheels	51 in.
Journals, diameter and length:	
Driving, main	11½ in. by 14 in.
Driving, others	11 in. by 13 in.
Front truck	7 in. by 12 in.
Trailing truck, front	6½ in. by 12 in.
Trailing truck, back	9 in. by 14 in.
Boiler:	
Type	Straight top
Steam pressure	225 lb.
Fuel	Bituminous coal
Diameter, first ring, inside	82$\frac{7}{16}$ in.
Firebox, length and width	130 in. by 90¼ in.
Height mud ring to crown sheet, back	65½ in.
Height mud ring to crown sheet, front	86¾ in.
Arch tubes, number	4
Combustion chamber, length	None
Tubes, number and diameter	19, 3½ in. 37, 2¼ in.
Flues, number and diameter	182, 3½ in.
Length over tube sheets	20 ft. 6 in.
Grate type	Cast steel
Grate area	81.5 sq. ft.
Heating surfaces:	
Firebox	253 sq. ft.
Arch tubes	35 sq. ft.
Tubes and flues	4,203 sq. ft.
Total evaporative	4,491 sq. ft.
Superheating	1,965 sq. ft.
Comb. evaporative and superheating	6,456 sq. ft.
Tender:	
Style	Water bottom
Water capacity	10,000 gal.
Fuel capacity	18 tons
General data estimated:	
Rated tractive force, 85 per cent. engine	42,400 lb.
Rated tractive force, booster	10,900 lb.
Weight proportions:	
Weight on drivers ÷ total weight engine, per cent	53
Weight on drivers ÷ tractive force	4.3
Total weight engine ÷ comb. heat. surface	53.1
Boiler proportions:	
Tractive force, engine ÷ comb. heat. surface	6.6
Tractive force, engine × dia. drivers ÷ comb. heat. surface	518.8
Firebox heat. surface ÷ grate area	3.5
Firebox heat. surface, per cent of evap. heat. surface	6.4
Superheat. surface, per cent of evap. heat. surface	43.8

Effected Economies in Locomotive Operation

Part of the story of the reduction in the Pennsylvania Railroad System's operating ratio for 1926 to 77.5 per cent, the lowest in many years, is told in the economies effected in locomotive operation. For each hundred miles run by locomotives in 1926 the total cost for repairs, depreciation, fuel, lubricants and enginehouse expenses was $35.67, as compared with $40.21 in the previous year, a reduction of $4.54, or over 11 per cent.

At the close of the year, exactly 95 per cent of the locomotives of the Pennsylvania Railroad Regional System were in good working order, an unusually high average.

Railway and Locomotive Engineering

A Practical Journal of Motive Power,
Rolling Stock and Appliances

Published Monthly by
ANGUS SINCLAIR COMPANY
136 Liberty Street, New York
Chicago Office: 168 North Michigan Avenue
Telephone Rector 0746. Cable Address "Locong," N. Y.

Harry A. Kenney, Prest. and Man. Ed.
W. E. Symons, Associate Editor
J. Snowden Bell, Associate Editor.
Thomas P. Kenney, Secretary.

LONDON REPRESENTATIVE
The Locomotive Publishing Company, Ltd., 3 Amen Corner, Paternoster Row, London, E. C. England.

SUBSCRIPTION PRICE

$2.00 *per year,* $1.00 *for six months, postage paid in the United States, Canada and Mexico. For other parts of the world,* $2.50. *Single copies, 20 cents. Remit by Express Money Order, Draft, Post Office Order or Registered Letter.*

Mailing address can be changed as often as necessary—always give old and new address, and if you subscribe in a club, state the name of the agent.

Please give prompt notice when your paper fails to reach you regularly.

Entered as second-class matter January 15, 1902, at the post office at New York, New York, under the Act of March 3, 1879.

Baldwin Locomotive No. 60.000

In another column of the present issue will be found a description and report of tests of the three-cylinder compound experimental locomotive built by the Baldwin Locomotive Works and bearing their shop number 60,000.

There are several interesting features of the design, which reflect the present trend of thought of those engaged in the solution of railway motive power engineering problems. Notably among these features might be mentioned: high steam pressures and compounding, which are generally accepted, both here and abroad, as established and essential features by designers of ultra-modern highly efficient locomotives; steam pressures of 200 to 225 pounds are now quite common practice, while 235 to 250 pounds would seem to be about the limit that can be employed with flat stayed surfaces. Therefore, water tube fireboxes are employed for pressures of 350 and 400 pounds, with the conventional design of fire tubes in the barrel or cylindrical portion of the boiler.

The 60,000 not only has the above mentioned features of design, but after a satisfactory road service test, underwent a thorough test at the testing plant of the Pennsylvania Railroad the results of which gives ample evidence of the merits of these improved features in boiler and machinery design.

It is worthy of note from a study of the tables giving the test results, that the back pressure on the pistons was relatively low when considered in connection with boiler and steam chest pressures under various performance conditions.

The overall efficiency of the complete unit is well reflected in the fact that at a speed of 15 miles per hour, 1471 horsepower was developed with an average of 1.8 pounds of coal per horsepower, while at a speed of 37.6 miles per hour, 4515 horsepower was developed with an average of 2.6 pounds of coal per horsepower.

Both of these records bear testimony as to the high degree of efficiency of the 60,000.

Tax Burden Heaviest on the Railways

Despite the consistent tax reduction program carried on by the Federal government since 1920, the steadily increasing state and local government tax levies, combined with a considerable decrease in net income, resulted in a total tax burden on incorporated business that was heavier in 1924 than it had been in 1923. More than one-third, or 36 cents out of every dollar of the combined net income of all incorporated business concerns in the United States was absorbed by tax levies of the Federal, state and local governments in 1924, as against 27.7 per cent in 1923, according to a study of the trend of taxation in the United States now being made by the National Industrial Conference Board.

While the incidence of Federal taxes on corporations can be ascertained within a fairly short time, the incidence of state and local taxes involves a lag of several years. Hence, 1924 is the latest year which can be analyzed in the manner set forth above.

The total amount contributed by the corporation of the United States toward the support of the Federal, state and local governments in 1924 was $2,541,007,000, which was paid out of a combined net income of $6,995,900,000 and of the total tax $1,586,536,000 went into the treasuries of state, municipal and local governments. While the total amount of taxes paid by corporations in the United States in 1924 represented 2.1 per cent of their combined gross receipts, the total of dividends paid by all corporations represented only 3.6 per cent of their gross receipts, it is pointed out by the Conference Board.

The railroads in 1924, on the other hand, had to pay 5.8 per cent of their gross receipts in dividends.

The position of the railroads since 1920 has never been so favorable as that of industrial corporations generally. During this entire period the railroads have had to pay out more in taxes than they could disburse in dividends.

Fuel Saving Is Greatest Ever

Greater efficiency than ever before in the use of fuel by road locomotives was accomplished by the Class I railroads in 1926, according to reports for the year just filed by the railroads.

An average of 137 pounds of fuel was required in 1926 to haul one thousand tons of freight and equipment, including locomotive and tender, a distance of one mile. This was the lowest average ever attained by the railroads since the compilation of these reports began in 1918. The best previous record was established in 1925 when the average was 140 pounds.

Record efficiency in the conservation of fuel was also shown for the passenger service, the average amount for the year used in that service having been 15.8 pounds to move each passenger train car a distance of one mile. The best previous low record for this service was in 1925, for which the average was 16.1 pounds. In 1920, the average was 18.8 pounds.

Class I railroads in 1926 utilized for road locomotive fuel 101,007,549 tons of coal and 2,067,272,099 gallons of fuel oil. In each instance, theses amounts were somewhat greater than in 1925. This increase in the aggregate consumption of fuel was due wholly to the increased traffic handled.

There has been a steady increase in the conservation of fuel on the part of the railroads of this country since 1920. In part this has been due to the construction of improved locomotives built with a view of increasing the tractive power while at the same time reducing the amount of fuel needed to operate them. Educational programs have also been carried on by the railroads to instruct firemen as to the proper method of smoking locomotives and to encourage fuel conservation.

Caution Will Make Grade Crossings Safe

There are 242,807 highway crossings passing over railroads, according to the American Railway Association. During the past five years, 3,059 were eliminated. Yet, during these same five years 17,553 new crossings were created, making a net increase of 14,494 crossings over those in existence in 1920.

More than 20,000,000 automobiles are registered in the United States. Their field of operation is every highway —every crossing.

In 1925, the American Railway Association states, 2,206 persons were killed and 6,555 injured at highway grade crossings. Automobiles were involved in 84 per cent of these casualties.

The complete separation of railroads from highways would eliminate these mishaps, the Association explains, but its accomplishment would require generations of time and cost about $19,000,000,000. Pointing out that immediate remedies must be sought, the Association offers the following suggestions as part of its campaign to reduce accidents at highway grade crossings:

The separation of the highways from railroads should proceed in an orderly and consistent manner.

Public authorities should discourage the creation of new crossings.

Highways should be re-routed, where practicable, to avoid crossing railroads.

Railroad crossings should be clearly and uniformly indicated to highway traveler.

Due notice should be given of the approach of trains.

Traveler's view of approaching trains should be improved where possible.

Extreme care should be exercised at every railroad crossing—no matter how rusty the track may appear.

Warning signals should be obeyed by highway travelers.

Where it is obligatory to stop before passing over railroad tracks, there should be no equivocation; an *actual stop*, plus observation, should be the rule.

Every highway traveler should look and listen where such acts will avail him.

Drivers of automobiles should be competent, trustworthy, and of good habits.

Reckless driving over railroad crossings should be condemned.

All efforts to prevent crossing accidents should be encouraged.

The three C's, Cross Crossing Cautiously, should be indelibly impressed upon every automobile driver.

Electrically Refrigerated Dining Cars

The development of electrically refrigerated dining cars, capable of transcontinental trips without icing, is announced by the Chicago, Milwaukee & St. Paul Railway.

Marked economies of operation over the ordinary iced dining cars and complete elimination of food spoilage, even in summer, distinguish the invention, it is announced. The new diners develop their own electrical power for refrigeration from batteries which float on the lighting system of the train.

Since 1872, when the first dining car appeared on American railroads, it has been the practice to ice the refrigerators by hand. Under the high temperatures developed in the galleys, frequent stops were necessary for re-icing.

In the early days, before artificial ice was developed, elaborate preparations were necessary to lay in a store of ice cut from frozen rivers and lakes. Even after the process of making artificial ice was discovered, great difficulty has always been experienced in maintaining even temperatures in dining car refrigeration. Heavy waste through spoiling of food resulted. The development of electrical refrigeration, it is believed, will eliminate all such difficulties.

The St. Paul's announcement is made only as a result of exhaustive tests which began last spring. Mechanical refrigeration on railroad dining cars, regarded as one of the hardest problems in the engineering field, was worked out by L. N. Jones, superintendent of dining and sleeping cars, in co-operation with the manufacturers of electrical refrigeration devices.

An experimental installation was made in April, 1926. The electrifically refrigerated diner was immediately put on a special train through the West. On the same train was a second diner with a refrigerator box of similar capacity, in which the ice was used. During the trip a careful check was kept to determine the relative efficiency of the two boxes.

"Much to our surprise," said Mr. Jones, "the electric refrigerator cost less for maintenance, although we have always been able to buy ice at a very low figure. And what was more important, our loss through food spoilage, which has always been large, was practically eliminated. This is the first successful installation of electric refrigeration on American dining cars. Similar equipment has been used on the "Flying Scotsman," the crack Midland train between London and Edinburgh, for more than a year.

"Because of the necessity of conserving every inch of space in dining car galleys, it is impossible to have the refrigerators more than a yard away from the ranges. In summer temperatures as high as 165 degrees are developed. Ice melts rapidly in such heat, which is equal to that in a steel mill."

Locomotive Refinements

To the Editor:

Interest in unusually large types of locomotives has, for the moment, obscured certain important considerations which affect the design of the more commonly used classes of engines, and has thus deferred, temporarily at least, the formulation of a well-defined policy in regard thereto.

Up to recent years, the Pennsylvania had done more in the direction of refinement of detail than any other railroad; though it is only fair to acknowledge that the advent of the super-locomotive hastened consideration of this matter throughout the country.

A study of the modern motive power of a certain prominent road reveals some rather interesting facts, however, which are the more surprising in view of the progress made elsewhere within the past decade. For example, on Pacific type engines of rather moderate dimensions, this road uses cross-heads and guides of a massiveness that would answer the purposes of locomotives twice their size. These cross-heads are of the alligator type, a style long popular because of its strength and the ease with which the guides can be kept in alignment. Their disadvantage lies in the fact that they add weight at a point where it is not needed, especially in these days of special steels and scientific designing.

Box-guides with underhung cross-heads of the type developed on the Pennsylvania are sufficiently strong to take any of the stresses commonly experienced by locomotives of average size and capacity. The truth of this statement has been demonstrated very conclusively by that road's classes K-4-s and I-1-s, of the Pacific and Decapod types, respectively; to say nothing of the L-1-s, M-1 and C-1, the latter being of the Mikado, Mountain and 0-8-0 types, respectively.

These neat and light cross-heads and guides will be found, also, on the Pacific type engines of the Reading and of the Central of New Jersey, as well as on the smaller locomotives of various other roads.

The practical man does not need to be told that a reduction in reciprocating weights is a distinct advantage, and that any savings thus gained—or by any means gained—may be applied to an increase in boiler capacity. That is where the increase ought to go, and where it is going on up-to-date roads.

Many who read this will recall that, some years ago, the Reading placed in service the first of a very interesting group of Pacific type locomotives in which the boiler capacity, fire-box volume and grate area necessary to sustained high speed were made possible by very ingenious reductions in the weights of moving parts. The boilers of these engines were, and are, straight or very nearly so. The latest examples of this type on the Reading have wagon-top boilers, and one of them is shown herewith at Atlantic City, where many people admired it, as may be judged from the picture.

The same principles which were so successful in the design of these engines are applicable to various other types, wherever used; and it is, therefore, reasonable to expect that these principles will be considered when the question of "new power" comes up in the future. It is only natural, of course, that each motive power officer should desire to "try his hand" at his favorite "stunt;" but there are limits to the extension of such a policy.

Many of the unusually large locomotives of recent years were designed for service on mountainous divisions; and, hence, cannot be regarded as typical of the requirements of the country, as a whole. After all, there is a vast low-grade mileage in the United States on which the familiar types of the day render the best service. When speaking of service it is important to remember that both initial cost and cost of maintenance must be considered very carefully in connection with specific conditions. This explains why conservative roads decline to adopt certain devices and appliances. Their managements feel that, however successful such devices may be on other roads, there is no necessity for them on their own, and that their adoption would merely introduce new and undesirable problems.

There is nothing, however, against the general principle of refining the details of locomotive design. The particular details referred to hereinbefore have interested various roads in the West, though their solution of the question has been different from the one already outlined. On the Burlington, for example, the Laird cross-head is used on large Pacific type engines, Mountain Mikado and Santa Fe type locomotives.

A recent account of motive power development on this road includes interesting references to the careful revision of the design of the more important machinery details of the principal classes of locomotives; an achievement in which the Baldwin Locomotive Works has taken a very creditable part. The result is a material reduction in the revolving weights without any sacrifice of structural strength, capacity or operating efficiency. These improvements point the way to a success unheard of in any previous epoch of locomotive engineering.

Questions covering the possible advantages of three-cylinder locomotives, novel types of boilers and various other departtures from commonly accepted practice will be solved as time goes on. Just now, however, there is a good opportunuity, for improvement on many roads in the direction already suggested.

Those interested in this subject must have noticed the very instructive articles which have appeared in recent issues of RAILWAY and LOCOMOTIVE ENGINEERING on the progress made in Germany and elsewhere; though, of course, this advance is concerned very largely with locomotives having three or four cylinders. Even so, the same ideas are feasible in connection with locomotives of the familiar two-cylinder single-expansion type. All that is required is a little enterprise backed by a few dollars added to the initial cost of each engine: an expenditure that does not figure again during the life of the locomotive.


Reading Pacific Type Locomotive Exhibited at Atlantic City

In order to understand fully the meaning of refinement of detail it is necessary only to look back a few years and think of the largest locomotives then in use and of their relative inefficiency as compared with engines of not much greater weight today. If a man cannot grasp the situation after that, his case is hopeless!

Those of use who have an abiding faith in the steam locomotive have much to be thankful for; not the least of our blessings being brought to us by those who shared that faith at a time, when visionaries were crying their wares in the market place! ARTHUR CURRAN.

Cost of Dining Car Service

The Norfolk and Western Railway served 248,056 travelers in its dining cars last year—and lost slightly more than 31 cents per meal served, according to data recently compiled and announced by the railway. The loss, which amounted to $77,081.02 is not considered extraordinary, the railway being partly repaid by the good will and comfort of its patrons.

The revenue from the railway's dining cars last year totalled $289,303.35, or $1.166 per passenger served. The expenses in connection with dining car service were $366,384.37, or $1.477 per passenger served, leaving a deficit per meal served of 31.1 cents.

The total expense of operating dining cars last year—$366,384.37—was divided as follows: The actual operating expense was $299,508.83; renewal of equipment (china, glassware, linen, etc.) amounted to $2,875.54; the expense of overhauling dining cars periodically amounted to $20,800; cleaning, minor repairs, etc., amounted to $7,200 and interest on the investment in twelve all-steel dining cars amounted to $36,000.

The Electric Locomotive for Railroad Service

By F. E. WYNNE, Railway Equip. Eng. Dept., Westinghouse Electric & Manufacturing Company

Although railroad electrification is only 32 years old, the variety of electric locomotives built and placed in service is legion. There are certain major points indicating the path of progress to date. A review of these in chronological order with relation to some of the distinct American types will give you a bird's-eye view of the present position of the electric locomotive and explain the lack of standardization which yet exists. In this discussion we shall omit consideration of multiple unit motor cars and confine our remarks to locomotives.

The first commercial electric street car system began operation in 1888 and it was only seven years later that the initial application of electric locomotives on a steam railroad was made by the Baltimore & Ohio Railroad. The danger and discomfort of grade operation of their Baltimore tunnels with steam power led that railroad to purchase three 96 ton electric locomotives. At that time the 600 volt, D.C. system was the only one available and a third rail contact line was used for distributing the heavy currents to these 1080 H.P. locomotives. The locomotive cab was mounted on two swivel trucks, like a street car, but the motors were mounted concentric with the axles and without gears. As with any pioneer machinery or application, these locomotives were highly educational to both the railroad men and the designers. However, they proved effective. Their record stands as evidence of the reliability of electrical apparatus well maintained, for these original heavy locomotives were not retired from service until 25 years after they had been placed in operation.

During the period from 1896 to 1901, no locomotives were built for steam railroad electrification, but some experience was secured through the manufacture and operation of quite a number of locomotives from 30 to 65 tons for electric railways.

In 1902, the Italian State Railways placed in service two 900 H.P., 51 ton, swivel-truck locomotives using four geared motors. This was the first practical acknowledgment that high voltage on the distribution system would be necessary for the railways as well as for power transmission. These locomotives were 3000 volt alternating current units with 15 cycle induction motors. The increase in voltage and the use of alternating current on the line were important advances in railroad electrification. However, the engineers at this time apparently failed to recognize the handicap inherent with two trolley wires over each track and the difficulty of controlling a number of induction motors in parallel.

Recognition of this latter fact became apparent when this same railroad, in the following year, placed in service three 68 ton, 1200 H.P., 3 phase locomotives with only two motors on each. These two motors were connected to the middle driving axle by a Scotch Yoke and the three driving axles were coupled by side rods. In addition to being the first rod locomotives, they were the first units with guiding axles (one at each end) and one of the first two applications of the type with all driving axles in a rigid wheel base and having the cab built solidly on the engine frame.

The other application of this type appeared in the same year in four additional 600 volt D.C. locomotives for the Baltimore & Ohio Railroad. Each of these rated 800 H.P. and weighted 80 tons, but differed from the original B. & O. engines in that they were primarily for freight service (speed 8 M.P.H. vs. 17.5 M.P.H.), the motors were geared instead of gearless, and the wheel diameter was 42 inches instead of 62 inches. This application recognized the principle that low initial cost in freight locomotives requires geared motors, which have been a feature of all American freight locomotives since that time.

In the following year, 1904, a geared locomotive known as the No. 10001 was built for the Pennsylvania Railroad. This unit embodied the feature of articulated trucks which has been prominent in many later locomotives. This type of construction introduced two desirable factors; first, the drawbar-pull was all transmitted through the truck frames, thus reducing the weight of the cab underframing and giving a direct line of action from coupler to coupler; and second, the rigid wheel base was shorter than with the second B. & O. type with a consequent reduction in the punishment on track and wheel flanges. Two years later, a similar locomotive, the No. 10002, was built for the Pennsylania Railroad, with gearless motors.

The first single phase locomotive blossomed forth in Germany in 1905. It was a rather puny infant, weighing only 22 tons and rating 180 H.P. at 11 M.P.H. A single phase motor was geared to each of its two axles. However, it had a notable characteristic in that it operated from a 15,000 volt trolley line. The demonstration that such a high potential was practical for trolley lines and locomotives led to the adoption of 15,000 volts as the standard pressure for distribution on the electrified railroads of Austria, Germany, Norway, Sweden and Switzerland.

The serious condition with steam operation in the Park Avenue Tunnel of the New York Central Railroad in New York City led to legislative action which gave the first real impetus to heavy electric locomotive construction in this country. Both the N. Y. C. and the New Haven use the former's track between the Grand Central Terminal and Woodlawn—a distance of twelve miles. In 1906 the first electric locomotives for both of these roads were delivered.

The New York Central conservatively adopted the well-known 600 volt D.C., third rail system while the more progressively inclined New Haven selected the then novel 11,000 volt, single phase overhead trolley system. This difference in systems made it necessary for the New Haven locomotives to be arranged to operate from D.C. on the N.Y.C. tracks as well as from single phase on the N. H. tracks. The original locomotives for both of these electrifications were for passenger service only and all of them were built with gearless motors which logically fit in passenger service if anywhere. However, they were widely different in type. The New York Central had four motors with armatures mounted solidly on the axles which were in a rigid wheel base, and there was a guiding axle at each end. The New Haven had the motor armatures mounted on a quill surrounding the axle and supported by the motor frame with a large clearance between the quill and axle. The torque was transmitted from the quill to the wheels through eccentric springs permitting relative movement of the quill and axle. Swivel trucks without articulation and without guiding axles were used originally. However, serious nosing developed in operation and it became necessary to add a guiding axle to each truck. Mr. Lamme's single phase series motor with resistance leads was used. To date these New Haven locomotives have made approximately 1,500,000 miles each in high speed passenger service. In addition to being the first heavy single phase electrification, the New Haven had the honor of demonstrating that 25 cycles is a suitable frequency for such service.

Dangerous tunnel conditions were the prime cause for the electrification of the St. Clair Tunnel of the Grand Trunk Railway for which locomotives were delivered in 1908. When this project first came up, there was great argument as to whether single phase motors would be suitable for developing the heavy starting torques required with freight trains. So Mr. Westinghouse had a locomotive (No. 9) designed and built with characteristics suitable for the St. Clair Tunnel. This was an articulated locomotive, each half having 3 axle hung, geared motors in a rigid wheel base with the cab built solidly on the locomotive frame. As the motors were quite heavy, spring suspension was used to relieve the axle bearings of the motor weight usually carried by them. No. 9 was used to demonstrate the starting capabilities of the single phase motor, a successful tug-of-war between it and a steam locomotive being staged on the bank of Turtle Creek in the presence of a large crowd of railroad men. With some modifications and improvements, near duplicates of No. 9 were furnished the Grand Trunk Railway and have been remarkably successful. An additional unit of this type will be shipped to this same customer this year. Equipment for 28 units of this type have been delivered within the last year to the Pennsylvania Railroad for switching locomotives. Part of these will be used on 600 volt D.C. at New York and the remainder on 11,000 volt single phase at Philadelphia. The substantial duplication of this type after 18 years is most comforting as it indicates that sometimes we build better than we realize at the time.

Meanwhile the three phase overhead trolley system had been making progress in Europe, particularly on the Italian State Railways. The year 1909 saw the beginning of operation of the Cascade Tunnel of the Great Northern Railway by this system. While 3,000 volt, 16⅔ cycles had been used abroad, this installation was made at 6,600 volts, 25 cycles. The locomotive had articulated trucks with twin geared axle hung motors. This was the only 3 phase railway installation in America. The best commentary on the system is that for the extension just now being placed in operation single phase with motor-generator locomotives was selected and the 3 phase system is being scrapped.

In 1910, the first articulated locomotives with one gearless D. C. motor on each half were placed in service at the New York Terminal of the Pennsylvania Railroad, As is their practice, the railroad built the mechanical parts of these engines. Each motor, through inclined rods, drives a jackshaft which is connected to the driving wheels by side rods. The wheel arrangement of each half unit is a four-wheel truck followed by two driving axles. A novel feature of the motor is a slip clutch built within the armature with a view to preventing extreme damage with excessive torque. Simultaneously articulated locomotives with one gearless single phase motor on each half appeared on the German State Railways and on the New Haven Railroad. The German locomotive had the jackshaft between drivers and the New Haven was without jackshaft, the main rod running directly from the motor to the pin in the driver. Both of these engines had a single guiding axle on each half.

The Hoosac tunnel on the Boston and Maine Railroad, was electrified in 1911 with the 11,000 volt single phase system using series motors. These were of the articulated truck type with one motor quill geared to each driving axle. In starting from the yards outside of the tunnel, the steam locomotive assists but it is pulled through the tunnel without working. In the same year quill geared articulated truck switchers were placed in operation in the electrified yards of the New Haven Railroad. At this time the New Haven Railroad and the Westinghouse Electric & Manufacturing Company joined in the development of several locomotive types for the purpose of getting locomotives more powerful than the original gearless "ponies" and also in order to secure for both passenger and freight service locomotives that would be duplicates except in gear ratio. In addition to the articulated gearless side rod type previously mentioned, three articulated truck types with quill geared motors were built. One of these had plate frames and a twin armature motor driving each axle. Weight limitations imposed by the New York Central Railroad placed a premium on weight reduction and this plate frame locomotive was the lightest of the trial engines. Unfortunately it was also the least accessible for inspection and repairs. The other two trial engines had bar frame construction and a single motor driving each axle. Refinement in detail mechanical design made the second one of these 40,000 pounds lighter than the first one, but yet some 16,000 pounds heavier than the plate frame design. From the tests and service operation of these four trial locomotives, an articulated truck type with one guiding axle and two driving axles per truck, bar frames, and one quill geared twin motor on each driving axle was evolved and thirty-nine of these units were built and placed in service in 1912-13.

The Piedmont and Northern Railway has been electrically operated from the first and so its locomotives do not come within the classification here being discussed. Nevertheless, I mention it in passing because it was a definite step in the development of the high voltage direct current system. The locomotives had 750 volt motors connected two in series and insulated for 1,500 volt trolley. The information developed in building and operating these locomotives was important in pointing the way to the successful manufacture of locomotive equipment for higher D.C. voltages which came into common use later.

The following year, 1913, witnessed the opening of electric operation at 2,400 volts D.C. on the Butte, Anaconda and Pacific Railway with 80 ton articulated truck type locomotives with four axle hung geared motors. Here the service was quite light on account of the major tonnage being handled down grade and the problems encountered and solved were principally in connection with the high voltage. In the same year, the New York Central Railroad extended their N. Y. terminal electrification and because of the longer run with heavier trains, a new locomotive type was developed. The gearless motor with armature built on the axle as in the previous design was retained but the eight motors were mounted on four trucks. The cab rested on the two intermediate truck frames which were articulated. The outer end of each of these intermediate frames rested on a swivel truck.

To the Norfolk and Western Railway belongs the distinction of first applying (in 1915) electric locomotives to heavy freight duty. They selected the single phase system on account of its marked advantages in the distribution of power to heavy trains. In handling the coal trains on this road the starting conditions are very severe and the specifications stipulated that the locomotive should be able to exert full tractive effort at standstill for five minutes. Although this was later found to be an exaggeration of the actual requirements in service, it led to the choice of the polyphase induction motor taking power from the single phase line through a transformer and phase converter. The tractive effort in starting was regulated by liquid rheostats in the traction motor secondary circuits. The operation of this road, being quite different from and in some respects more severe than any electrification previously undertaken, developed certain elements of design and construction for heavy electric motive power. A few of these are:

(1) Locomotive frame strength and rigidity are more important than light weight.

(2) Forces resulting from inertia effects of rotating masses connected to the drivers impose upon parts of the locomotive structure stresses far in excess of those encountered in steam locomotive practice.

(3) Fine dynamic balance of rotating machinery is essential.

(4) Rigid mounting of heavy rotating machinery is desirable.

(5) Transformer protection against heavy surges in line voltage is essential.

(6) Balanced currents in the phases of the traction motors are necessary at all times when exerting full load tractive effort or more.

The utilization of the new information resulting from this electrification has proven an important factor in the successful manufacture of later locomotives. The grades on this road made it possible to demonstrate the effectiveness and safety of utilizing the inherent characteristic of the induction motor for the regenerative braking of heavy trains.

The Chicago, Milwaukee & St. Paul Ry., which to the layman is the most spectacular and best advertised electrification, began electric operation in 1916 and was the first 3,000 volt D.C. installation. Initially some of the locomotives were geared for passenger train speeds but all of those placed in service at that time now have the freight gearing. The experience secured on the 2,400 volt B., A. & P. job proved valuable for the C., M. & St. P. so that the increase in voltage from 2,400 to 3,000 was not a large step and the C., M. & St. P. was quite successful electrically from the beginning. Each motive power unit had two articulated trucks with a guiding truck at the outer end of the unit and the two units back to back formed one locomotive. The twin geared axle hung motors were wound for 1,500 volts, insulated for 3,000 volts, and connected in groups of two in series. The electrified zone crossed three mountain ranges. It was realized that regenerative braking would be a valuable asset in operation under such conditions for it increases safety, reduces wear and tear on equipment, and decreases the consumption of electric energy. As the direct current series motor requires special connections, apparatus and control to make it function as a practical generator on locomotives, a system of regeneration was developed and applied to these locomotives.

Prior to this time the Pennsylvania Railroad had placed in operation a single phase suburban electrification at Philadelphia with the intention of using that system for future electrification. This afforded them a place to try out single phase locomotives. Following their practice of building experimental engines before embarking on any extensive program, in 1917 they placed in service a trial split phase freight locomotive, known as the FF-1. This is the most powerful motive power unit ever built, rating 4,800 H.P. for one hour and 4,000 H.P. continuously at 20 M.P.H. This is an articulated truck engine with one guiding and three driving axles per truck. Between the guiding and front driving axle of the truck is the jackshaft, which is driven by two motors through flexible gears. On the Norfolk & Western locomotives two operating speeds were secured by changing the number of poles on the traction motors as the major portion of the service is given at the lower speed. On the FF-1, provision for securing half speed by cascade connection of the motors was used because of its simplicity and very little half speed operating being contemplated. Among the major improvements in the equipment, as compared with the original Norwolk and Western locomotives, were the wound rotor phase converter with provision for maintaining approximately unity power factor and the rectangular tank, distributed electrode form of liquid rheostat.

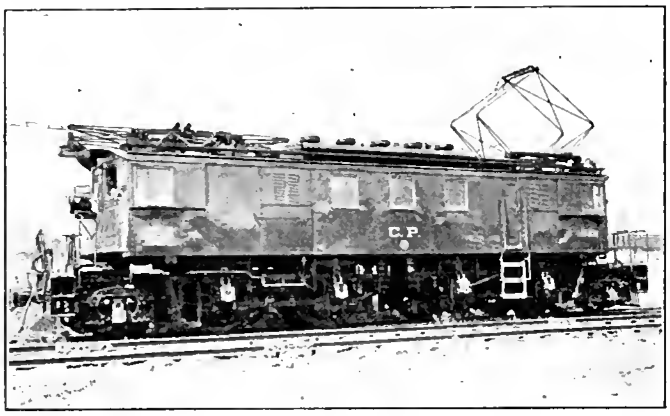
The gradual extension of the electric zone and the increase in train size on the New Haven made it imperative that they secure more powerful passenger locomotives and led to the development of their Class 0300 type, the first of which went into service in 1919. The success of the quill geared twin motor locomotives which were built seven years previously made it logical to retain the same general features and to secure the fifty percent increase in power desired by adding motored axles. As the rigid weight limitations were yet controlling, additional carrying axles also were required and this in spite of a large weight saving due to the use of integral cast steel truck frames. The complete 2,500 H.P. locomotive weighs slightly less than 180 tons. The cab is mounted on two articulated trucks, each of which has a guiding axle at each end and three driving axles.

About the same time the Chicago, Milwaukee & St. Paul, being well satisfied with their initial electrification, decided to electrify two engine districts over the Cascade Mountains, to buy new regenerative passenger locomotives and to convert their old passenger power into freight engines. The new passenger locomotive, of two types, were placed in service in 1920. Five of these followed the general gearless motor design which had been used extensively by the New York Central and ten were of the general quill geared twin motor design which had been so successfully used by the New Haven Railroad. The use of the gearless motor in such a snowy locality developed in service the necessity for protecting high voltage motors from the direct entrance of snow while securing adequate ventilation. The quill geared locomotives had 63,000 pounds per driving axle, (fifty percent more than on the similar New Haven power) the track was rather rough, and the cab rested on the trucks through multiple supports. Service soon developed failures of wheel spokes and quill springs, which caused the quill drive to be redesigned as one step in the correction of the difficulty. In the new design the quill was not attached to the wheel through the springs but it carried cups completely enclosing the springs and making contact with pads on the wheel spokes. The springs are always worked in compression and spring breakage has practically vanished. An interesting and economical feature of these locomotives is the motor grouping which provides for operation at one-third, two-thirds and full speed and is an improvement over former three-speed controls where the combination gave one-quarter, one-half and full speed.

This control improvement was next embodied in the freight locomotives which entered service in the Paulista Railway of Brazil in 1921. These articulated truck locomotives had three axle hung, 1,500-volt motors in each rigid wheel base and were arranged for regenerative braking, each motor was wound for 1,500 volts and insulated for 3,000-volt operation. They were the forerunners of the Chilean State freight locomotives and of additional freight engines for the Paulista.

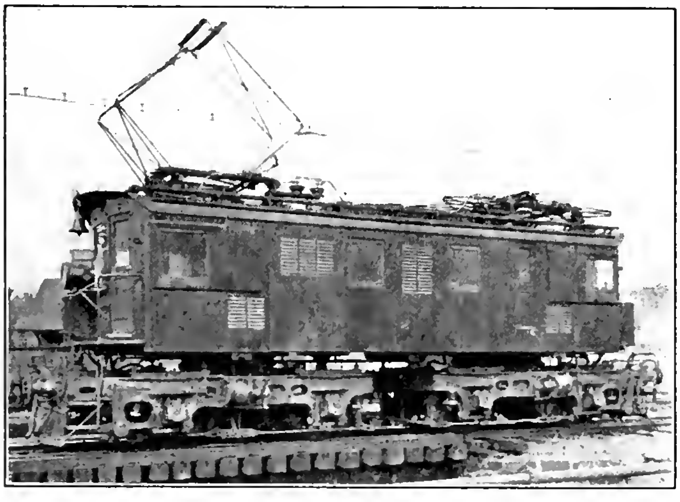
In this year, there appeared in Switzerland a novel form of drive which has proven very successful for passenger service. It is known as the Buchli drive. The connection between the gear and the wheel is made by pins and links in such a way that the wheels and axles are free to move relative to the motors mounted on the locomotive frame as with the quill drive. In the same year the American form of quill drive was applied to some passenger locomotives for the Swiss Federal Railways.

The Chilean State Railways electrified their line between Valparaiso and Santiago in 1923 with the 3,000-volt D.C. system for which four types of locomotives were furnished. The freight locomotives were of the Paulista type, somewhat refined in design and with the weight reduced. The express passenger locomotives had the same driving wheel arrangement as the freight engines but the motors were more powerful and the higher train speed made it seem desirable to add a guiding axle at the outer end of each truck. The local passenger locomotives of 80 tons embodied integral cast steel truck frames which were required to meet weight limitations. An interesting development for these locomotives was a single frame twin armature motor-generator set with the motor windings in series and the generator armatures in parallel.


Central of Paulista Passenger Locomotive

Simultaneously the Mexican Railway electrified with the same system a slow speed, heavy grade section using locomotives having axle hung motors mounted on three two-axle articulated trucks.

The year 1924 was a most noteworthy one in that three new types of large single phase locomotives were delivered. The idea of using a single phase trolley line with a motor-generator on the locomotive to receive alternating current from this line and to deliver direct current to the traction motors is quite old. It had been held in abeyance for years awaiting the development of rugged, stable, light weight motor generator sets. The idea behind such a locomotive is to get the advantages of a high voltage single phase trolley line and also those of the low voltage direct current traction motor, together with a flexibility of control which permits the development of the full locomotive H.P. output over a wide speed range. This latter characteristic of the motor generator locomotive is closely approximated in the modern steam locomotive and has many advantages in train operation. When it was determined that a suitable motor-generator design had arrived, the motor-generator locomotive idea was sold to Henry Ford and he placed the first two units of this kind in service on his Detroit, Toledo, Ironton Railroad. The mechanical parts were built in his factories and designed by his engineers in collaboration with the designers of the electrical equipment. Each motive power unit is articulated and has eight axle-hung, twin-geared motors. The locomotive has no frame in the ordinary sense of the word. Instead of journals and boxes there is a solid axle bearing in the motor frame. The four motor frames of each half unit are connected in tandem through projections on the frames. Other projections extend upward from the motor frames and on these rests a backbone casting through which the draw-bar-pull is transmitted and in which the ventilating ducts are cast. The cab is attached solidly to this backbone. The multiplicity of motors resulted in a relatively long cab and the layout of the apparatus in it gives a very pleasing roomy appearance, although its arrangement is not the most desirable from the standpoint of inspection and repair. With a view to future extensive electrification, this installation and the apparatus for it were designed and built for a trolley pressure of 22,000 volts, but is operated for the present at 11,000 volts. On account of the higher voltage and following successful European locomotive practice, oil insulated transformers with forced ventilation and cooling of the oil were applied. Other novel features of these locomotives included flexibility in the motor shafts, a combined controller and brake stand, throttle type controller handles moving in a vertical plane, individual air brake cylinders for each wheel, heavy nickel trimmings and finish and aluminum chain with deep upholstered seats for the engineman.


Chilean State Local Passenger Locomotive

New York, New Haven and Hartford Locomotive

The second new single phase type of 1924 was the Class L-5 Pennsylvania locomotive having the wheel arrangement of a Mikado steam locomotive and designed as a common purpose, system locomotive so that freight and passenger units would be identical except for gearing. It is of the geared side rod type with a jackshaft between each guiding axle and the adjacent driving axle. Each jackshaft is driven through flexible gearing of the radial leaf spring type by two commutating pole, single phase, series motors without resistance leads. This construction made the distance between the guiding axle and drivers unusually great and the Pennsylvania engineers designed and applied a novel form of double link truck to secure sufficient lateral motion of the guiding axle. Several additional locomotives of this type have been built and a number are on order with the exception that they have the necessary direct current control equipment to permit their temporary operation on the New York terminal lines.

The third new single phase type of that year appeared in the 4750 H.P. split phase locomotives for the Norfolk and Western Railway. Each of these engines was composed of two geared side rod motive power units, each of which also had the Mikado wheel arrangement. Each jackshaft is driven by one three phase motor and the two motors of one unit are controlled by a common motor operated liquid rheostat with provision for independent adjustment of the load on the individual traction motors during acceleration. Oil transformers were applied in combination with resistance type circuit breakers which were an innovation on American locomotives. The phase converter was arranged for approximating unity power factor as in the Pennsylvania FF-1 locomotive. The mechanical parts were designed by the railroad and their consulting engineers and included a new type of motor bearing housing for insuring accurate maintenance of gear center distance with easy renewal of motor bearings. The gearing for these locomotives and for the Pennsylvania L-5 had to transmit loads and meet other requirements far beyond the previous field of experience.

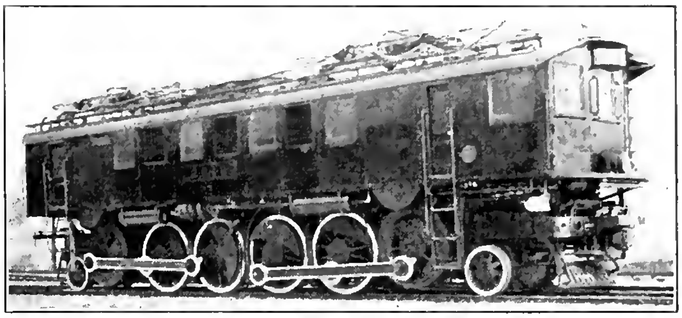
In 1925, the Virginian Railway inaugurated electric operation with the single phase system and split phase motive power units similar to the Norfolk and Western engines of the preceding year. The requirements on the Virginian Railway were so much more severe than those of the Norfolk & Western that each locomotive was composed of three motive power units, totaling 7125 H.P., with all necessary provision for future operation of four units as one locomotive if required. As on the N. & W. the heavy grade operation is effected with one locomotive pulling at the head of the train and a second locomotive pushing at the rear. On the sections of easier grade on both roads, the train is operated without a pusher. The Virginian electrification includes two long grades (one of 11 miles and the other of 7 miles) both with the load. Consequently this road has a much greater opportunity than the N. & W. to realize the benefits of regenerative braking. Like the Detroit, Toledo & Ironton installation, the Virginian Railway is equipped for future operation with 22,000 volts on the trolley if desired.

Last year a switching locomotive weighing 100 tons, of the storage battery type with a gasoline-electric auxiliary, was placed in operation in the Chicago yards of the Chicago and Northwestern Railway. There is little novel about this unit except the source of power. It remains to be seen whether it is a practical and economic unit.

Some time this month the first of the motor-generator type, single phase locomotives will begin operation on the Great Northern Railway, including the Cascade Tunnel formerly operated by the three phase system. In a paper three years ago we stated that it was improbable that any extension of electrification by the Great Northern would continue the three phase system. The present situation is the fulfillment of that prediction. Electrically these new locomotives are quite similar to those of the D., T. & I. However, each motive power unit has the Mikado wheel arrangement with four axle hung geared motors. Two of these units form one locomotive but provision is made for the operation of one unit alone if desired.

Locomotives now on order for delivery this year include single phase switcher and passenger engines for the New Haven, a single phase unit for the Grand Trunk Railway, 3000 volt D.C. freight, passenger and switching engines for the Paulista Railway and single phase motors with D.C. control equipment for the Pennsylvania New York terminal.

The locomotive with an internal combustion engine driving a generator which in turn furnishes power to the traction motors is in the process of development and service proof. There are many railway lines where a well developed unit of this class will meet the demand for more economical operation without the burden of an electrical distribution system. The internal combustion in the twilight zone between the logical fields of steam and all electric operation. It is expected that some of the lighter operations, such as switching and branch line operation of small trains, can employ successfully gasoline-electric units, while the heavier and probably greater portion of the zone will be covered by the oil-electric engine. The electric portion of such development involves few serious problems. The success of the entire undertaking depends upon the development of an oil engine of reasonable weight and cost which will also be economical to maintain and operate. In view of the continuous accomplishments of engineering in the development of electric locomotives to meet all the requirements of railroad service, I venture to predict that adequate and satisfactory internal combustion locomotives with electric drive will be available for application in the near future.



One Motive-Power Unit, Norfolk and Western Locomotive

Pennsylvania's New Passenger Coaches

A new type of all-steel passenger car, embodying important innovations and improvements, has just been adopted by the Pennsylvania Railroad as its standard for through express service. The improvements include an entirely new interior color design, brighter lighting, and larger toilet and washroom facilities, easier riding qualities and increased comfort in seating.

The ceilings of the new coaches are painted light ivory instead of the green hitherto used, and the power of the lamps has been increased 50 per cent. The result is a much brighter and more cheerful car. The sash of green glass, which, in the older type, extends the full length of the car just below the ceiling, has been eliminated and a continuous sheet of metal substituted. The light ivory paint used on the ceiling extends down over this metal sheet to the sides of the car.

The seat backs have been made two inches higher, to give better support to the head, and add to the comfort and enjoyment of the ride. The windows are equipped with exceptionally heavy weather stripping, entirely preventing the discomfort of drafts in cold weather. At the same time, the windows have been so designed that any tendency of the sash to work open from the bottom is altogether eliminated.

Seventy-four cars of the improved design have just been received and placed in operation. Cars hereafter built, or ordered, for through express passenger service will be of this type.

Committee Reports to the Convention of the A. E. R. A.

Cost of Impurities in Locomotive Water Supply and the Value of Water Treatment

Between locomotives running in district with naturally good boiler water and locomotives running in district with excessively bad water there is a difference of cost of boiler repairs and fuel of about $4,000 per engine per year; By the use of water softening methods now available to anyone some of these very bad water districts have had their boiler repair and fuel cost reduced $4,000 per engine per year and their operating cost reduced in like amount; while district with water less bad have had their costs reduced in proportion and at the rate of $1,000 per engine per year in repairs and fuel for each ten-grains-per gallon of hardness in the water, and an equal amount in general operating expenses.

Nearly all river and well water of the level country require treatment to remove either hardness or mud or both, and with approximately 16,000 railroad water stations and something like 350 billion gallons of water used annually by the railroads for locomotive purposes, of which about 80 per cent would be improved by treatment and only 15 per cent is treated, the most valauble contribution that can be made by this committee or this association to the water service of the railroads of the country is to make everyone acquainted with the fact so that an annual and unnecessary expense of something like $100,000,000 may be eliminated.

Last year we discussed the various methods for water softening in use on railroads, and mentioned the zeolite method as suitable for certain kinds of water and as being tested by the Southern Pacific Company at Los Angeles, Cal. We are now advised by Dennistown Wood, engineer of tests that this railroad has found the zeolite method satisfactory for stationary boilers and locomotives, that zeolite softeners have been installed at five points with five similar plants under construction at other points and the report says, "With the plants already installed we are experiencing practically no trouble from foaming."

The relative insulation qualities of carbonate and sulphate scales; is difficut of experimental determination in locomotives because they seldom take one kind of water only, and the best laboratory measurements of which we have knowledge are those made by Professor Schmidt at the University of Illinois, as follows:

Character of Scale	Thickness	Composition	Per Cent Loss
Hard	1/50 in.	Mostly Carbonate	5.4
Soft	1/32 in.	Mostly Carbonate	7.2
Hard	1/32 in.	Mostly Carbonate	8.5
Soft	1/25 in.	Mostly Carbonate	8.0
Hard	1/25 in.	Mostly Sulphate	9.3
Hard	1/20 in.	Mostly Sulphate	11.1
Soft	1/16 in.	Mostly Sulphate	10.8
Soft	1/16 in.	Mostly Carbonate	11.0
Soft	1/16 in.	Mostly Carbonate	12.4
Hard	1/16 in.	Mostly Carbonate	12.6
Soft	1/11 in.	Mostly Carbonate	15.0
Hard	1/9 in.	Mostly Carbonate	15.9

From this it appears that the difference in heat losses between carbonate and sulphate scales per se is negligible and that the differences in insulating quality which are found are due rather to differences in density and mechanical structure.

Many careful calculations are on record to show that locomotive fuel losses in United States on account of scale in boilers are not less than $50,000,000 per year, and the damage to boilers is as much more, these two items making up the $100,000,000 per year of unnecessary loss mentioned above, which can be rapidly reduced by a campaign of education.

Economical Spacing of Water Stations

One of the most important factors limiting the length of a non-stop run is the question of water supply and fuel for the locomotives. In this matter the problem of water supply is of especial importance as the use of this commodity will exceed that of coal between 600 to 900 per cent in weight.

Engine districts will vary in length depending upon local conditions but the average appears to lie between 100 and 150 miles. The ideal condition would appear to be in furnishing locomotives with sufficient water and fuel so that no stop for this material would be necessary between terminals.

A method taken by some railroads to reduce the delays from water stops has been the installation of track pans. However, the expensive maintenance of such equipment, including the mechanical as well as the track facilities, has held up consideration of such installation on many railroads.

During the past few years, experiments have been made with increasing the size of locomotive tanks. Whereas a capacity of 10,000 gal. was formerly considered exceptional, the use of six-wheel trucks has permitted additional loading so that there are now many engine tenders in service holding 16,000 gal. of water and on one railroad tanks with a capacity of 21,000 gal. are in use.

It was formerly considered good practice to locate water stations on an average spacing of from 15 to 20 miles consistent with local conditions. On railroads where the large engine tanks have been placed in service water station requirements have changed radically and a possible spacing of between 30 and 60 miles is indicated as satisfactory. This fact is favorable from a water service standpoint to the extent that it permits concentration of facilities with greater opportunity for giving all water used better attention, and also allows better selections as to quality of supply.

The foregoing report was presented by the chairman of the committee, Mr. C. R. Knowles of the Illinois Central Railroad.

An Analysis of the Costs of Starting and Stopping Trains

A method of determining the cost of stopping and starting trains was developed and the results that have been deducted from an analysis of the expense items incident to train service was submitted. In this analysis the cost of wages, locomotive and car repairs, depreciation and retirements were based on the time lost to produce service, while the remaining expense items were considered on the basis of the additional amount used because the train stopped as compared with these items on a non-stop train.

The study was confined solely to through freight train operation as it was found impracticable to include passenger train operation.

Aside from the time element involved, which affects wage (when on overtime) and equipment costs, the principal items of expense are fuel and water. To determine these the study was based on a large number of dynamometer records which were obtained on the Chesapeake & Ohio during the summer and fall of 1925. These tests were made in through freight service with full tonnage trains, using Mikado locomotives having a tractive effort of 67,700 lb., on grades ranging from level to 1.25 per cent. The remaining items, which were determined on the basis of the amount used, including lubricants and other supplies for locomotives, and train supplies and expenses, were obtained by applying the ratio of that part of these accounts which would be affected by a train stop to the cost of the fuel and water. The method of doing this was outlined in considerable details in the report.

Train stops were classified under three groups, each of which would be affected by the varying conditions under which they might be made. These were: (1) Anticipated schedule stops; (2) anticipated stops not scheduled; and (3) emergency stops.

The schedule stops does not normally involve serious loss in the hire of equipment, whereas the unscheduled may cause a serious loss in this item and may so interfere with schedules as to have a far reaching effect upon other trains, while an emergency stop may produce a noticeable damage to the rails and locomotive tires and increased brake show wear; in addition, such stops frequently result in the shifting of lading causing damage to both equipment and contents. It was not found practicable to outline rules for determining all the costs that pyramid by reason of unscheduled and emergency stops. Such costs can only be surmised and left to be considered as local conditions may warrant. For these reasons the study was confined to individual train stops that come under the three classifications mentioned.

While it was found impossible to develop a formula for determining the cost of a train stop that can be applied generally and that such a formula would probably not be applicable on two different roads or two different divisions or two different trains, and in many instances two different stops of the same train, the committee endeavored to develop a method by which the formulas can be readily adapted to the different conditions which may be encountered.

The report discussed in detail the various items which have been enumerated and developed formulas for the number of pounds of coal and gallons of water lost in stopping and starting freight trains on any grade. For the purposes of this study the cost of other supplies for train locomotive was estimated by multiplying the time lost on account of the stop by 30 per cent of the cost of this item per train hour for the train service involved. It was assumed that the cost of train supplies and expenses is not affected by the number of train stops made between terminals.

The cost of locomotive retirements, including interest on the investment in the locomotive, was based on the cost of ownership which was assumed to be 0.75 mills per pound of tractive effort. This value will vary for different roads and must be computed for each road before it is applied in the formula. The cost of freight train car repairs, depreciation and retirements on account of train stops is determined by the value of the car-day which was assumed at $1 per car-day, based on either the cost of ownership or the cost of hire in the same manner as these items apply to the locomotive.

The following recapitulation was given to show the items that should be considered in determining the cost of stopping and starting a 5,000-ton train consisting of 70 loaded cars, on an overtime basis, running at a speed of 25 miles an hour on a descending grade of 0.5 per cent, and accelerating it to the same speed on an ascending grade of 0.25.

	Cost
Wages for train and enginemen	$1.2944
Fuel for train locomotice	.7000
Water for train locomotive	.0467
Lubricants for train locomotive	.0247
Other supplies for train locomotive	.0053
Train supplies and expenses:	
Locomotive repairs, depreciation and retirements, including interest on investment	.4972
Car repair, depreciation and retirements, cluding interest on investment	.6854
Total Cost	$3.2537

Methods of Operation by Which the Intensive Use of Facilities May Be Secured

This subject is so similar to that preceding it that it was decided to confine attention to the consideration of those means by which the capacity of a line can be increased without the expenditure of any considerable amount of money. This demarcation left a very limited field because relatively few measures can be taken to increase capacity without the expenditure of money.

Two investigations were undertaken, both of which are in the early stages, as follows: (1) The use of the No. 19 train order in place of the No. 31 order as a means of reducing delays to train, thereby increasing the number of trains that can be handled over the line in a given period; (2) a study of methods employed by the Canadian Pacific and Canadian National railways to handle their peak load grain traffic between Winnipeg and the Port Arthur-Fort William terminal each fall which involves the transportation of a maximum traffic for a period of approximately 60 days, equal to more than three times that handled during the remainder of the year. On the Canadian Pacific the number of freight trains operated daily between these points averages 10 during the 10 normal months, rising to an average of 35 and a maximum of 41 during the grain rush. The committee felt that a study of the methods by which the peak traffic is handled without increasing the investment that will be idle or little used during the remainder of the year will afford some interesting illustrations.

Suitable Units for Costs of Operation and Equipment Maintenance

Inasmuch as a liberal interpretation of the subject might have carried the scope of the study too far into the specialized fields of the transportation and mechanical departments, the committee concluded that, in the absence of arrangements for joint consideration with appropriate committees from those departments, it would be proper to limit this report to a brief survey of available statistical units and other data in the fields of train, locomotive, car, engine terminal, yard, and station operation and to confine it to the freight service. Specifically, the committee attempted to suggest an answer to such a question as this: In a case where there has been a substantial additional investment in such items as grade revision, reduction in distance, increase in double track sidings, yard capacity, automatic signaling, and the like, what factors may be taken into account in comparing the operation results prior and subsequent to the expenditures to see whether the expenditures were justified?

Unfortunately it is rarely possible to paint a statistical picture which will reflect accurately the before and after results from the viewpoint of any single major factor, such as a grade reduction, a cut off, a program of additional trackage, a new engine terminal, or other intensive revision or enlargement of a terminal or an intermediate yard. Changes in the volume or the mature of the traffic handled, differences in weather conditions, changes in wage rates or working rules, fluctuations in the prices of materials and fuel, and differences in the number and degree of casualties, together with accounting exigencies which make it impracticable to avoid substantial adjustments which either adversely or favorably affect one or both of the two periods, frequently obscure or nullify the results which would be apparent had the traffic characteristics and all other factors been identical in each period. A before and after comparison, therefore, is always surrounded by qualifications, many of which are not susceptible of exact measurement. Since, however, statistics at best are merely aids to judgment, and may properly be used only as such, the committee suggested units of performance, costs, and income that might be helpful in such a comparison.

Nothing was suggested that may not be compiled currently from available statistics of practically all railroads, and the greater part of the basic data are now required by the Interstate Commerce Commission in the monthly or annual reports to the body. An ideal scheme would embrace a more comprehensive schedule with many desirable subdivisions in detail (such as those in connection with locomotive and car repair costs), but the committee did not consider it advisable in this report to go beyond the available data except in a few instances to suggest the desirability of greater detail. The committee merely suggested a summary of what it considered the best of the available and common units of comparison. They were grouped under three headings; (1) Physical performance—operating statistics in which the dollar mark does not appear; (2) unit costs—which are to be studied in connection with physical performance; and (3) traffic, revenue and income factors.

Effect of Motor Trucks and Bus Lines on Branch Line Operation

At the close of 1925 there were more than twenty million motor vehicles in use on the highways of this country, or more than one car for every six persons. The tremendous growth of motor transport since the World War has been accompanied by an equal growth in the mileage of improved highways. This mileage in the United States was estimated on January 1, 1926, at three million, of which one-half million or 17 per cent was surfaced. The rapid increase in the mileage of surfaced roads has made possible the corresponding increase in the number of motor vehicles. Possibly these facilities are not being used to capacity, but the unknown number of passenger miles and ton miles moving over the highways is so great that traffic on the railroads is being seriously affected.

The number of passengers carried by rail reached its maximum in 1920 prior to the advent of motor transportation on a large scale; in 1925 the smallest number in the ten-year period was recorded—28 per cent fewer than 1920 and 12 per cent below 1916, a pre-war year. The number of passenger miles also reached its peak in 1920, but the decrease since that year has not been so noticeable as in the case of the number of passengers. Before the World War there was a steady increase in passenger miles. A continuation of this increase would logically have occurred after the war; therefore the decrease that has taken place is especially significant.

While the decrease in the number of passengers carried has been general throughout the United States, it has varied widely in magnitude in different areas. Thus, while the number of passengers carried in the first nine months of 1926 is less than in the same period in 1922 in all districts the amount of the decrease in these four years range from 1.3 per cent in the Great Lakes district to 41.7 per cent in the Southwestern district.

When the statistics of passenger travel are separated into those covering commutation traffic and those covering all other traffic, further light is thrown upon the source of the loss of passenger business. On the basis of the first nine months of the respective years the number of commutation passengers increased from 319,197,000 in 1922 to 331,314,000 in 1926. The number of other than commutation passengers, however, decreased in the same period from 404,308,000 to 314,850,000, and this loss is primarily in the short haul traffic.

The average length of journey by rail, which was abnormally high in 1917, 1918, and 1919, due to troop movement, reached 40.5 miles in 1925, a longer distance than was recorded in any previous year in the period, and probably the longest ever reported in this country. The reason for this is that though long distance travel has been increasing the local, short distance travel has been decreasing. This decrease has not been in the commutation business that moves at less than standard rates, but in the first class ticket sales, generally considered the most profitable kind of passenger traffic. The net result of these two influences has been a more or less steady decline in passenger revenue since the peak in 1920, although an increase in passenger fares became effective late that year. Passenger revenue was smaller in 1925 than in any year since 1918. The decline in the sale of first class tickets is also reflected in the revenue per passenger mile, which has shown a steady decrease since 1921, the first full year in which the present schedule of fares was in effect.

As a result of the loss of this short haul traffic the average journey per passenger has increased as is shown by the following figures for all passenger traffic for commutation passenger traffic and for passenger traffic other than commutation.

These reductions in passengers, passenger miles and passenger revenue are not the result of curtailment in passenger service; in fact, they have occurred in the face of a constant increase in the number of passenger train miles, this number in 1925 being greater than in any year since 1927, when troops were being assembled. As a result the average number of passengers per train decreased to 62.6 in 1925, the lightest loading since 1916. Similarly the number of car miles and the average number of cars per train have been increasing in spite of reductions in traffic, each item reaching a maximum in 1925, in which year the average number of passengers per car reached it minimum. Regardless of what may have happened in individual cases, the general statement may be made that the deflection of passenger traffic from rail to highway was not primarily the result of curtailment of rail service.

It is thought that the diversion of passenger business from the rail to the highway has been caused largely by the increasing use of the private automobile. In addition to the private car, the public conveyance or motor coach has made heavy inroads on rail passenger traffic in the last three years. On January 1, 1925, there were approximately 53,000 buses in service, virtually all of which had come into existence within the previous year or two, while on January 1, 1926, this number had grown to 70,000. Interurban electric lines and city rapid transit companies now own large fleets of motor coaches, and have thus protected their revenues. On the other hand, the steam railroads, with a few exceptions, have been slow to make use of this new method of transportation, with the result that some of the more profitable traffic has been captured by their new competitors. Some of the business will be recaptured by the operation of buses owned by the railroad or their subsidiaries.

The field of the motor coaches outside of the cities should be limited to those sparsely settled districts where there is not sufficient traffic to justify the operation of passenger trains; to those districts where there is sufficient traffic to warrant the furnishing of both kind of service (in which case the highway operation should be performed by the existing rail carrier); to those districts where accommodation train service can best be performed by buses in conjunction with express service by rail, the two forms of service being properly co-ordinated. Within its field bus transportation should not be opposed by the railroads; rather it should be encouraged by its adoption wherever it presents the most economical method of transporting passengers. The duty of railroad management, therefore appears to be the direction of the public's desires, so far as direction is possible, along proper lines, keeping highway transportation in its legitimate field, and not being slothful in providing it where it is the best transportation tool for the purpose.

It is significant that the average haul obtained by dividing revenue ton miles by tonnage originating on line has increased from 302 mile in 1916 to 332 mile in 1925, a figure that was not exceeded in the last ten years. It is a logical conclusion that this increase is due largely to the loss of short haul traffic to the motor truck. As in the case of the motor coach, the truck is well adapted to the furnishing of short haul transportation in limited quantities. In cities it is replacing the trap car for transferring less than carload freight between industries and freight terminals, and it is also replacing the freight car in intraterminal work. For short hauls of less than carload freight in city or country it provides cheaper and prompter transportation than the railroad train, especially when the cost of crating and packing and collection and delivery service are considered. In retail transportation it is preeminent; in wholesale transportation, measured either by bulk or by distance hauled, it is out of place and in its unregulated state a menace to rail carriers. It is probably not as serious a factor as the passenger car, because speed and economy govern its use, while in the case of the passenger car novelty and pleasure enter in to a large degree.

The field of the truck is limited in same way as that of the motor coach. There can never sufficient traffic be moved, in bulk or over long distances, to warrant two parallel services save as a temporary expedient: rail facilities should be expanded, if necessary, to handle all of this business that is offered. Of course it is true that a sudden emergency, such as a war or a serious labor difficulty may temporarily force wholesale freight traffic onto the highway. In the case of motor coaches, however, it is recognized that the situations may exist where parallel services, covering relatively long distances, are justified and should be maintained. Generally speaking, the fields of the truck and the bus are the same and the attitude of the railroads toward the truck should be similar to their attitude toward the bus; assisting it in its legitimate field, using it as an ally where it should be used and opposing it elsewhere.

Branch Line Abandonments

It is evident that highway transportation has a great field in the sparsely settled areas served by railroad branch lines, and the effect of this new method of transport on the carriers' secondary lines is important. It is a matter of common knowledge that many rail lines have been abandoned in the last five years on account of deficits resulting from motor competitions. It is also true that there are many rail lines now being operated at a deficit for the same reason; in general these should either be made to pay or be abandoned.

Unprofitable branch lines existed before the era of hard surfaced roads and motor transportation and to a limited extent abandonments were made. It is true, however, that the advent of motor transportation, both passenger and freight, on improved highways has had a great deal to do with increasing the number of losing branches and the degree of loss.

The situation must be met, either by using these new transportation facilities where they should be used and by discouraging their use elsewhere, or by surrendering to the competitor and salvaging what remains of a formerly profitable business. Each case must be determined on its merits, as only general rules can be laid down.

The Public Will Decide

The right of the public to determine for itself the means it will use for traveling and shipping is well recognized by the Interstate Commerce Commisison; the following is taken from a recent decision; "Applications for abandonment of steam railway operation appear to be only one of the many indications of disturbance resulting from the advent of the automobile and other industrial forces. The steam railroad is laboring under conditions which resemble in certain respects those encountered by the stage coach when the railroad came into the field. It will be admitted that people are entitled to the best and cheapest transportation they can get, and that they themselves must decide what is best and what is cheapest, all things considered. If people prefer to tax themselves to build great highways and to use commercial trucks and passenger vehicles in preference to the steam railroad, they have a right to their decision, but they must also assume the responsibilities, with the attendant consequences, of that decision."

As a result of all this strife, present and proposed regulation, fair and unfair competition, and the failure of the general public to figure accurately the cost of transportation that is provided partly by taxation, the railroad engineer has before him many new problems in the economics of branch line operation, the solution of which will require the highest analytical skill and a knowledge of virtually every branch of railroad business, including the fast growing portion that moves over the highway.

The foregoing report was presented by the chairman of the committee, Mr. James M. Farrin, of the Illinois Ceneral Railroad.

Railway Fuel Association Convention

A highly interesting program has been prepared for the nineteenth annual convention of the International Railway Fuel Association which will be held at the Hotel Sherman, Chicago, May 10 to 13 inclusive. Addresses will be made at the opening session by the president of the association and also by: Carl Gray, President, Union Pacific System; George Otis Smith, Director, U. S. Geological Survey, and by Dr. H. Foster Bain, Secretary of the American Institute of Mining and Metallurgical Engineers.

Individual papers and reports to be presented to the convention are as follows: "Operating Factors in Fuel Efficiency," by A. E. Warren, General Manager, Canadian National Railways.

"The Train Despatchers' Relation to Fuel Economy," by E. E. Regan, Genl. Superintendent, N. Y. N. H. & H. Railroad.

"Fuel Economies in Long Locomotive Runs," by T. H. Williams, Asst. Gen. Mgr., Southern Pacific Company.

"The Human Element in Fuel Efficiency," by H. S. Rausch, Div. Supt. Motive Power, New York Central.

"The Coal Industry," by Walter Barnum, President, National Coal Association.

"Preparation of Coal and Oil Fuel," Committee Report, M. MacFarlane, (New York Central) Chairman.

"Fuel Accounting, Distribution and Statistics," Committee Report, B. A. McDowell (B. & O.), Chairman.

"Storage of Coal and Oil Fuel," Committee Report, G. Warner (Pere Marquette), Chairman.

Addresses by L. K. Sillcox, Chairman Mechanical Division of the A. R. A., and F. S. Wilcoxen, Edna Brass Company, president of International Railway Supplymen's Association.

"Locomotive Economy Devices," Committee Report, Geo. E. Murray, (Grand Trunk), Chairman.

"Stationary Power Plants," Committee Report, R. S. Twogood, (Southern Pacific), Chairman.

"Firing Practice," Committee Report, J. M. Nicholson (Santa Fe), Chairman.

"Fuel Fundamentals," by N. D. Ballantine, Asst. to Pres't., (Seaboard).

"Diesel Locomotives," Committee Report, L. P. Michael (C. & N. W.), Chairman.

"Fuel Stations," Committee Report, L. J. Jaffray, (Illinois Central), Chairman.

"Fuel Bulletins," Committee Report, P. E. Bast, (Delaware & Hudson), Chairman.

"Co-operation with American Railway Association," Committee Report, E. McAuliffe, (Union Pacific), Chairman.

"Representation at Conference on Bituminous Coal," Committee Report, W. L. Robinson, (B. & O.), Chairman.

"Co-operation with Railway Accounting Officers Association," Committee Report, B. A. McDowell, (B. & O.), Chairman.

First Hole of Moffat Tunnel Completed

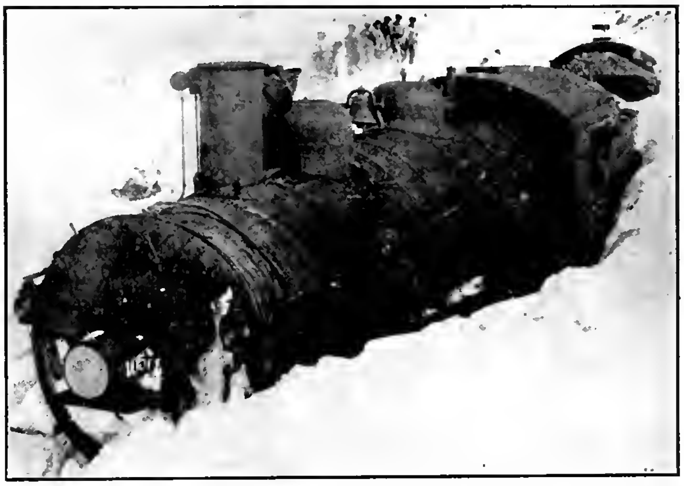
President Coolidge, by remote control, set off the blast which broke down the last barrier between the two bores of the preliminary work of the Moffat Tunnel, on Friday, February 18. Elaborate ceremonies in honor of the event were staged in Denver, conducted by Governor Adams of Colorado.

The preliminary tunnel completed by this blast is eight feet in diameter and has served as an exploration tube and, later, will be used as an aqueduct to carry water from the high western plateau in to Denver. Following closely on its heels is the construction work on the main tunnel, whose dimensions will be 24 feet by 16 feet.

The Moffat tunnel, boring under the Continental Divide, will be 6.04 miles long, the second longest tunnel in the world. It will be three miles shorter than that of St. Gothard under the Alps. Its completion will mark the culmination of a heroic struggle for the construction of a transcontinental route through Colorado, running from Denver to Salt Lake City. It will open the western slope of the Rocky Mountains to all-year traffic, connecting in the west with Moffat's original railroad below the snow blockage line. On the eastern side it enters the mountain at a point about 50 miles from Denver at an elevation of 9,198 feet. Near the middle of the tunnel the elevation is 9,222 feet—a peak or high point to allow ready drainage. The western portal has an elevation of 9,085 feet. The center of the tunnel is 4,160 feet below the top of James Peak. The grade on the eastern side is 0.3 per cent and on the western side 0.9 per cent. The tunnel passes directly under the Crater Lakes on top of the Continental Divide, locally reputed to be bottomless.

With the utilization of the proposed Dotsero cut-off, a 41-mile branch railroad to be built from the west portal of the tunnel, the distance from Glenwood Springs, on the west slope, to Denver, will be reduced from 343 to 173 miles. Dotsero and Glenwood Springs are now on the Denver & Rio Grande Western Railroad which goes far south to get around the snow line in the Colorado ranges of the Continental Divide. In addition, the tunnel will eliminate 23 miles of the railroad over Corona Pass, practically all of which is above timber line on a 4 per cent grade; will cut down the elevation by 2,406 feet, and reduce grades to 2 per cent.

The Moffat tunnel, in addition to its two railroad tracks, will be traversed by telephone, telegraph and power cables important to the life of the Rocky Mountain section. Automobiles will be carried through on flat cars, allowing motorists to make the trip over the Divide at all seasons. Present automobile highways between eastern and western Colorado cross the Divide by means of passes which are blocked half the year by snow. The railroad in the tunnel will be electrified, electric locomotives hauling the trains. The steam locomotives will have their fires banked and will be hauled through with the trains.



Bucking Snow on the Moffat R. R. This Part of the Line Will be Eliminated by the Tunnel

Tunnel construction work was started in October, 1923, under the direction of the Moffat Tunnel Commission and Tunnel District of Colorado. About 4,000 horsepower in electric motors has been and is being used in the work; motor generators and motor-driven compressors furnish light and power for excavation and construction; electric locomotives provide haulage facilities, and electric transformers supply power at proper voltages from electric transmission lines.

New Member of the I. C. C.

Ezra Brainerd, Jr., banker and lawyer, of Muskogee, Oklahoma, is the new Interstate Commerce Commissioner, succeeding Frederick I. Cox, of New Jersey, whose term has expired.

Mr. Brainerd was nominated by the President on February 16, was considered by the Senate Committee on Interstate Commerce on February 17, and was confirmed by the Senate immediately afterward.

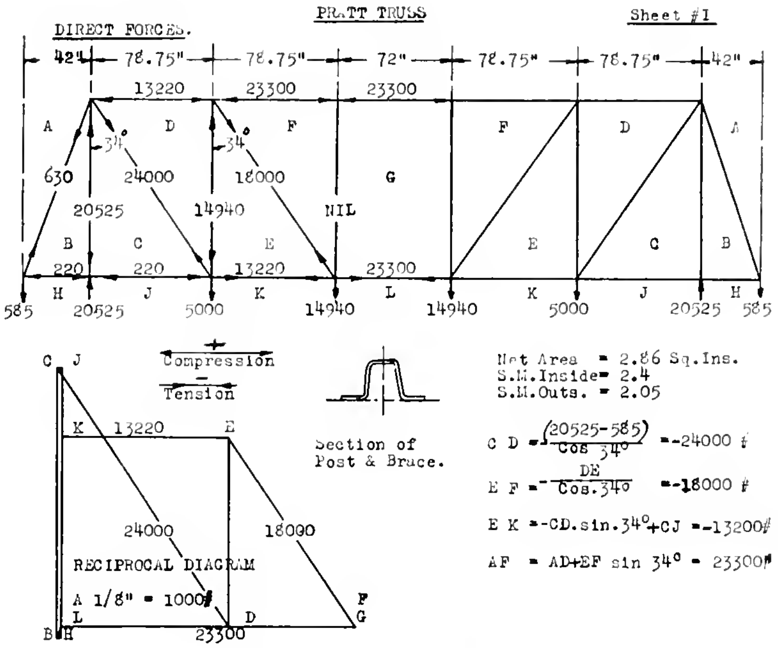
Mr. Brainerd is a Republican. He was born in Vermont in 1878, educated at Middlebury College, Colgate University and the University of Michigan. He received his law degree from the latter institution in 1904.

He has practiced law at Muskogee for some twenty years and has been Vice-President of the First National Bank of that city.

Box Car Side Frame Design*

By R. M. MOCHRIE, Draughtsman, Canadian Pacific Railway

The wood superstructure car was in universal use until 1907, when the steel superstructure made its appearance. The wood superstructure was replaced by the steel superstructure, just as the wood underframe was replaced by the steel underframe. The steel underframe wood frame car was hardly satisfactory, because of the continual repairs required to keep it intact on a rigid underframe. The posts and braces became loose; the frame and roof moved in all directions under severe shunting and overload conditions, that it was almost impossible to keep the sheathing, lining and roof on a car for a reasonable period of time.



COMBINED STRESSES # / SQ.IN. IN PRINCIPAL MEMBERS.

LOCATION.		MEMBER.	DIRECT. Inside.	DIRECT. Outside.	BULGING Inside.	BULGING Outside.	COMBINED. Inside.	COMBINED. Outside
POSTS	Between Supports	BC	9800	4510	4320	-5075	14120	- 565
		DE	7150	3290	3975	-4065	11125	- 775
	At Plate	BC	7300	7300	-5770	6750	1530	14050
		DE	5350	5350	-4620	5400	730	10750
	At Sill	BC	6200	6200	-8770	10150	- 2570	16350
		DE	5750	5750	-6950	8150	- 1200	13900
BRACES	Between Supports	CD	-8400	-8400	4250	- 4975	- 4150	-13375
		EF	-6300	-6300	4250	- 4975	- 2050	-11275
	At Plate	CD	-8400	-8400	-5750	6750	-14150	- 1650
		EF	-6300	-6300	-5750	6750	-12050	450
	At Sill	CD	-8400	-8400	-8500	9950	-16900	1550
		EF	-6300	-6300	-8500	9950	-14800	3650

The steel superstructure, while it has many distinct advantages over the wood frame has not been an unqaulified success. The posts, braces and connections break so frequently in the steel trusses of the single sheathed cars, that there is still much scope for improvements in their type. This short paper will deal exclusively with steel frames for single sheathed cars.

Difficulties in Design

At first sight the design of the side truss of a box car would seem a comparatively simple matter, and the structural engineer would probably smile at the idea of any calculations being required at all. This would be true, if the steel framing were utilized with slight modifications for a small truss girder bridge; then there would not be any failures in the stress members, because the factors governing them, could be accurately determined. It is when the steel work is placed on the trucks that the difficulties arise, and the frame members of the structure fail.

Oscillation end shock, longitudinal force and centrifugal force produce stresses and strains in the whole structure which cannot be accurately determined.

Oscillation in an overloaded car with the maximum side bearing clearances cannot be satisfactorily determined. While the effect of the force would be largely taken by the underframe members, it undoubtedly tends to produce unevenness at the supports for the truss members by the bulging of side plates and twisting of side sills.

The end shock produced by buffing may vary from 100,000 lbs. to 500,000 lbs. or more. Some cars may never be subjected to the former load, while others may have to stand a load in excess of the latter figures. The A. R. A. specify an end load of 250,000 lbs. This shock load is taken directly by the center sills, but a portion of it is transferred to the side frames and they must be prepared to absorb it.

The longitudinal shifting of loading is another force which varies greatly with conditions. It may cause the end posts of some cars to bulge 6 inches, yet in other cars of the same class, there may be very little bulging. Considering the force necessary to bend the end posts, it can be estimated, that the reactions at the end plates which are transferred to the ends of the side plates are approximately 15,000 lbs. at each end.

Centrifugal force may be calculated, but it is doubtful if the results would mean anything under actual conditions. Speed on curves is taken care of by the superelevation of the track so that the centrifugal force against the side on good tracks is practically nil. This force most probably is at a maximum when a slow moving freight train stops and starts on a sharp curve of maximum superelevation. A most severe condition exists on entering a curve, especially where the tracks are poor. The leading track shoots the outside corner of the car upwards while the rear truck is still on the level. This produces a diagonal twisting strain over the entire structure.

Causes of Broken Members

The causes of broken posts, braces and connections are due to (1) reduction of effective section, (2) poor rivets and riveting conditions, (3) unequal settlement of supports, (4) eccentricity, (5) cutting down of material.

First—The effective section in the members at the supports is reduced so much that it cannot resist the bending moments at the top and bottom of frames. Examination of broken part will show that the section modulus is pressed sections has been reduced over 50% of the value of that part between the supports. This reduction was made to facilitate riveting, but frequently it need not have been made at all, as the full section could have been carried the full length of post and satisfactory riveted conditions provided. The latest A. R. A. designs still show defects in this respect. Sheet No. 3 shows the S. M. at X-X for the A. R. A. brace reduced to .86 outside, which brings the stress up at this point to over 300,000 lbs. per square inch. The proposed brace end

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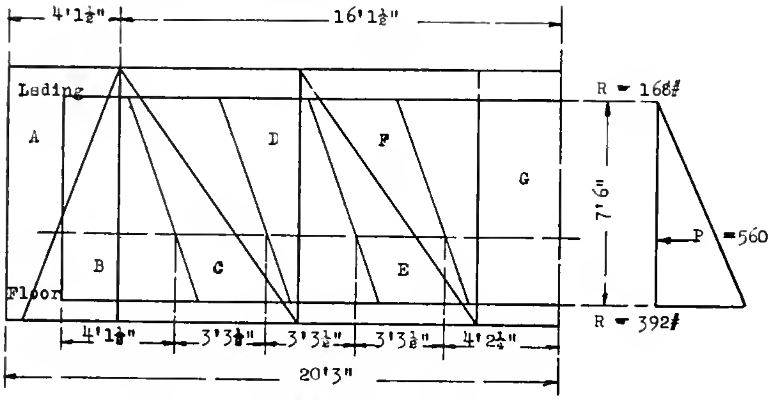
* *A paper presented before the Canadian Railway Club.*

shows the section carried down far enough to keep the stress at 16,900 lbs. per square inch as shown on Sheet No. 1.

Second—The rivets in these connections are usually poor on account of the unfavorable conditions existing at the juncture of the posts and braces; where the one is crimped over the other, and where the pitch of the rivets is sometimes no more than 2 inches. The edge distance and pitch area of the plates are seldom equal to the value of the rivets. These defects are common in pressed member trusses and still exist in the latest A. R. A. designs. (see Sheet No. 3) The edge area of the brace is only one-third the value of the rivet, and the pitch area (2" pitch) is only two-thirds the value of rivet. It may be argued that these areas have been taken horizontally, which does not represent the line of greatest force. The horizontal force is large enough, however, to justify larger edge distances on the plates. The crimped end in the tension member is not a good feature, as it tends to straighten out and thereby reduce the efficiency of the rivets. The proposed brace end shows the post compression member (which is not so highly stressed as the brace) crimped instead, and the other defects are practically eliminated.

BULGING IN SIDE MEMBERS

Sheet #2



$$P = \frac{WH}{2} \cdot \frac{1-\sin\phi}{1+\sin\phi} = \frac{49 \times 7.5^2 \times .58}{2 \times 1.42} = \underline{560\#\ \text{per Ft.Run}}$$

Posts calculated as fixed beams, 7.5' between supports with uniformly increasing load from Zero at top.

B.M. at top $= \frac{WL}{15}$ M_T for posts $= \frac{560 \times 90}{15} = 3360"\#$

B.M. at bottom $= \frac{WL}{10}$ M_B for posts $= \frac{560 \times 90}{10} = 5040"\#$

B.M. bet.supports $= \frac{WL}{24}$ Mx for posts $= \frac{560 \times 90}{20} = 2520"\#$

R at top $= \frac{3W}{10}$ Total M_T for BC $= 3360 \times 4.125 = 13860"\#$

R at bottom $= \frac{7W}{10}$ MT for Braces $= \frac{560 \times 112}{15} = 4180"\#$

TABLE OF TOTAL BENDING MOMENTS.

MEMBERS.	Top of Lading. AT SIDE PLATE.	Floor Line. AT SIDE SILL.	Between Supports. X = C.G. OF FORCE
Post BC.	13860 "#	20800 "#	10400 "#
Post DE.	11100 "#	16650 "#	8320 "#
Post FG.	14100 "#	21200 "#	10600 "#
Braces CD EF	13800 "#	13800 "#	10200 "#

Third—Bulging of the side plates or twisting of the side sills will cause unequal settlement at the supports for the posts and braces. It is not uncommon to find 2" to 3" off square laterally. The side members are considered by the A. R. A. as fixed, although they are at the best only half-fixed. In either case, however, it is essential for this type of beam, that the supports be absolutely equal. Structural engineers avoid fixed beams, because in fixing the ends securely, the tangents at each end of the beam must be absolutely horizontal, and any deviation from this will alter the stresses, and any difference of level at the two ends due to unequal settlement will cause considerable stresses in the beams.

Fourth—Eccentricity exists in every type side truss and varies from 2" to 9". In zee bar frames, where it is large, the failure of the connections is mostly due to eccentricity. It is not easy to eliminate eccencentricity as suitable riveting must be provided at the supports. The most suitable section for minimizing the eccentricity is the pressed section—the section is probably the most suitable from every point of view. The A. R. A. single sheathed box car designs show no eccentricity at the side plates, and the eccentricity is cut down to a minimum at the side by the use of this section.

Eccentricity can be determined by using the following formula:

$$\frac{\text{Safe Control load}}{\text{Safe eccentric load on member}} — \left(1+\frac{xdc}{r2}\right)$$

Fifth—The strength of the frame members is often sacrificed to save weight. For instance, in the A. R. A. bolster post the width of the post is 6¾"; It is secured by two ¾" rivets at 5" centers to the side sills by means of a cleat. This leaves merely ⅞" from the center of the rivet to edge of the plate. The strain of punching the holes, especially so near the edge, will damage the material to such an extent that what remains is probably not worth 20% the value of the rivets. The cumulative effect of the known and unknown forces acting at any joint in the frame is apt to open the material on the outside edge, and this will gradually tear across with repeated applications of these forces.

Design of Pratt Truss

Sheets No. 1 and No. 2 show the stresses worked out in the various members of a Pratt Truss for a 50-ton single sheated box car, 32' 3" centers of trucks. Sheet No. 2 gives the bending moments caused by the bulging load. This load is calculated by the Rankine theory of pressure on retaining walls—the angle of repose for wheat is taken at 25°. The A. R. A. use the "Influence Line" and "Formula" methods to calculate the B.M's., but either of these method is unnecessarily laborious. They assume the points of supports at the neutral axes of the side plate and side sill, but in reality, the points of supports are at the juncture of the members or along the lines of innermost connecting rivets. A table of total bending moments is compiled by the use of comparatively simple data, which give the B.M.'s at the floor line and load line, which lines coincide with the points of supports, top and bottom, at the juncture of the members.

Sheet No. 1 shows the direct forces obtained by the Reciprocal Figure and checked by calculation. A table of direct, bulging and combined stresses is given for the principal members. The top and bottom chords are subjected only to direct stress, while on the other hand the door posts are subjected only to bulging stress. There is a little secondary bending in the bottom chords in and near the doorway, but it is negligible.

The direct stress in post B.C. at sill appears small;

this is due to a larger area of plate being assumed at this point.

The stress in the compression posts between the supports has been calculated by the Rankine formula.

$$S=\frac{P}{A}\times\frac{1}{1+\frac{1}{25000}\left(\frac{1}{r}\right)^2}$$

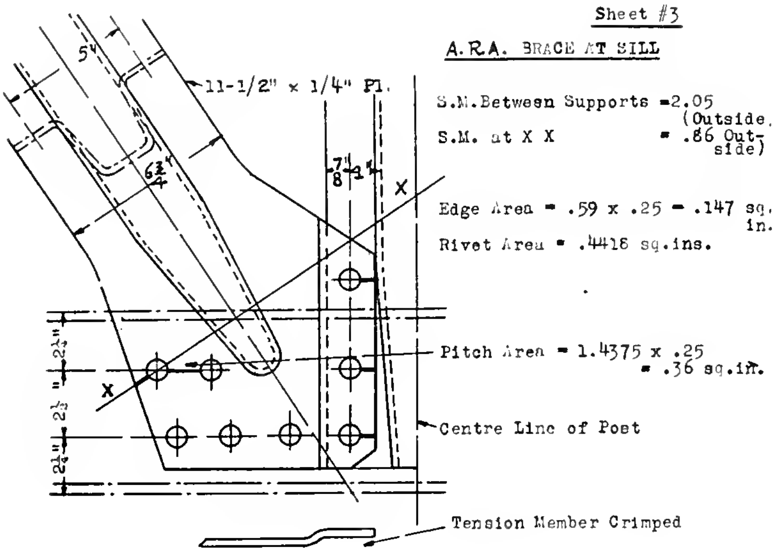
LOAD DISTRIBUTION

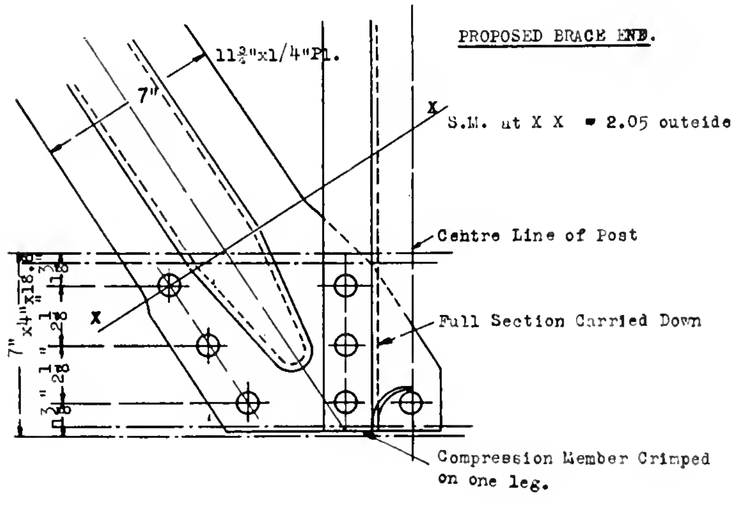
S in B.C = 20525 ÷ 2.86 × 1.37
=9800 lbs. per sq. in.

Weight on Rails		169,000 lbs.
Weight of Trucks		15,000 lbs.
Weight of Structure		154,000 lbs.
Weight of Ends	2,200 lbs.	
Load on Center Sills	90,100 lbs.	92,300 lbs.
Load on Side Trusses		61,700 lbs.
Load on One Truss		30,850 lbs.
Load per lin. inch		63.5 lbs.

FORCE A. H.

Uniform load 63.5 × 24	1525 lbs.
From Ends 2200 ÷ 4	550 lbs.
	2075 lbs.
Center Sill Reaction	1490 lbs.
	585 lbs.





FORCE J. K.

Uniform load 63.5 × 78.75	5000 lbs.

FORCE K. L.

Uniform load 63.5 × 75.38	4790 lbs.
Transferred from Crossbearer	10150 lbs.
	14940 lbs.

REACTION H. J. = 585 + 5000 + 14940 20525 lbs.

Baltimore and Ohio Celebrates Centennial

The one hundred anniversary of the granting of the charter to the Baltimore and Ohio Railroad Company was celebrated at the Lyric Theatre, Baltimore, on Monday evening February 28, by a dinner and historical tableaux. Throughout the century the Baltimore and Ohio Railroad has changed neither its corporate name, its charter, nor its fundamental organization.

This dinner was but the first event in the Baltimore and Ohio's observance of its centenary. Extensive plans for a pageant and transportation exhibit to be held in September have been made to which President Coolidge has been invited.

Invitations to the dinner on February 28 were extended to some eight hundred important railway and business men throughout the country, as well as a large number of representatives of the Army, Navy and Congress.

One of the many interesting features of the celebration was the souvenir medallion, reproduced herewith, which was presented to each guest. The medallion depicts one of the Baltimore and Ohio modern trains guided by the Spirit of Transportation, the reverse showing the "Tom Thumb" engine designed by Peter Cooper, the first steam locomotive built in America. Hans Schuler, Director of the Maryland Institute in Baltimore, designed the medal.

Daniel Willard, President of the Baltimore and Ohio, presided at the dinner. In his opening remarks he said in part:

"The twenty-eighth of February is significant in the history of the Baltimore and Ohio Railroad. It was just one hundred years ago today that the Legislature of Maryland passed the Act which was in effect the charter under which the Baltimore and Ohio Railroad Company was incorporated, and by virtue of which it has been operating continuously for nearly one hundred years.

"The Baltimore and Ohio Directors, having in mind the approaching centenary or one hundredth anniversary of the granting of the charter, felt that the occasion ought not to pass without appropriate recognition, and it seemed fitting that upon this date and in the city there should be a dinner to which should be invited not only the Governor and other distinguished officers of the state and city, but also the entire membership of the State Legislature, the direct successors of those who granted the charter one hundred years ago.

The Baltimore and Ohio Company some months ago appointed a Centenary Director, selecting for that position Edward Hungerford, a man of broad experience in such matters. Mr. Hungerford is also engaged in the preparation of a very complete history of the Baltimore and Ohio Railroad from its inception up to the present day. It is our present purpose to send a complementary copy of the history, when printed, to each of our dinner guests this evening.

"Mr. Hungerford has been generally in charge of the plans and details in connection with this banquet, and is also directly in charge of the plans which have been tentatively developed for the pageant and transportation exhibit to be held on Baltimore and Ohio grounds near Halethorpe in the western part of the City of Baltimore, beginning probably, on or about the seventeenth of next September. We hope that the President of the United States will be present at the opening ceremonies."

Newton D. Baker, former Secretary of War in the Wilson Administration and a Director of the Baltimore and Ohio, made the principal address. He said in part:

"The building of the Baltimore and Ohio Railroad and the other early railroads of the country, lies in to the political history of the United States through one of the most bitter of our early constitutional controversies. It took a long time to decide just how much of a nation had been established by the Constitution of 1789.

"Here lay this vast continent three thousand miles wide, settled and cultured throughout the relatively narrow strip at its eastern extent, but with a frontier encroaching on the wilderness by very gradual stages."

Notes on Domestic Railroads

Locomotives

The Chicago & North Western Railway is inquiring for a sixty-ton Diesel electric type switching locomotive.

The Canadian National Railways has ordered 10 locomotives for the Grand Trunk Western Railway 4 for the Central Vermont Railway from the American Locomotive Company, 10 switching type locomotives for the Grand Trunk Western Railway from the Lima Locomotive Works, 20 from the Montreal Works, of the American Locomotive Company, and 20 from the Canadian Locomotive Company, Ltd., Canada.

The Inland Steel Company has ordered one six-wheel switching type locomotive from the Baldwin Locomotive Works.

The Chesapeake & Ohio Railroad has given a contract for repairs to 18 Mallet type locomotives to the Newport News Shipbuilding & Drydock Company.

Pickands Mather & Company has ordered 2, six-wheel type switching locomotives from the Lima Locomotive Works.

The Denver & Rio Grande Western Railroad has ordered 10 Mallet type locomotives from the American Locomotive Company.

The Southern Pacific Company is inquiring for 10, 4-10-2 type three-cylinder locomotives.

The Terrocarril de Antioquia, Columbia, South America has ordered one Mikado type locomotive from the Baldwin Locomotive Works.

The De Queen & Eastern Railroad is inquiring for one Mikado type locomotive.

The Toledo, Peoria & Western Railway has ordered 4, Mikado type locomotives from the American Locomotive Company.

The Canadian National Railways has ordered 15 wing snow plows from the Eastern Car Company.

The International Lumber Company, Minneapolis, has ordered one eight-wheel switching locomotive from the Baldwin Locomotive Works.

The Duluth Missabe & Northern Railway is inquiring for 6, ten-wheel type switching locomotives.

The Missouri Pacific Railroad is inquiring for 5 locomotive tenders of 15,000 gal. capacity.

The Chicago & North Western Railway is inquiring for 8, eight-wheel type switching locomotives and 12, 2-8-4 type locomotives.

The Lehigh & Hudson River Railway has ordered two consolidation type locomotives from the Baldwin Locomotive Works.

The Barber Asphalt Company has ordered one six-wheel switching type locomotive from the Baldwin Locomotive Works.

The Maine Central Railroad has ordered 2 locomotive tenders from the American Locomotive Company.

The Minnesota, Dakota & Western Railway has ordered one, eight-wheel switching locomotive from the Baldwin Locomotive Works.

Freight Cars

The Chesapeake & Ohio Railroad has given contracts for rebuilding 250 steel hopper bottom gondola car bodies to the American Car & Foundry Company and 250 to the Richmond Car Works.

The Bangor & Aroostook Railroad has ordered 100 underframes from the Standard Steel Car Company.

The Chicago Burlington & Quincy Railroad has ordered 200 ballast cars from the Rodger Ballast Car Company.

The Atchison Topeka & Santa Fe Railway is inquiring for 150 caboose cars.

The Canadian National Railways has ordered 200 automobile cars from the Eastern Car Company.

The Union Railroad is inquiring for prices on repairs to 1,000 hopper cars.

The Norfolk & Western Railway is inquiring for prices on repairing and remodeling 1,000 hopper cars.

The Chicago North Western Railway has ordered 650 underframes from the Illinois Car & Manufacturing Company and 685 underframes from the Siems-Stembel Company.

The Fruit Growers Express has ordered 100 underframes from the Ryan Car Company.

The Chicago Burlington & Quincy Railroad has ordered 150 center sills for refrigerator cars from the Ryan Car Company.

The Swift & Company has ordered 300 steel underframes from the Pressed Steel Car Company for refrigerator cars, to be built in its own shops. The Western Pacific Railroad has ordered 100 ballast cars from the Rodger Ballast Car Company.

The Northern Pacific Railway has ordered 300 gondola cars from the Ryan Car Company.

The Canadian National Railways has ordered 100 ballast cars from the Rodger Ballast Car Company.

The Texas Company has ordered 300 of 8,000 gal. capacity and 100 of 10,000 gal. capacity from the Pennsylvania Car Company.

The Atchison, Topeka & Santa Fe Railway has ordered 50 ballast cars from the Rodger Ballast Car Company.

The Pere Marquette Railway is inquiring for 1,000 underframes.

The Great Northern Railway is inquiring for prices and repairs to 50 miscellaneous freight cars.

The Duluth, Missabe & Northern Railway is inquiring for 250 ore cars.

The Oliver Iron Mining Company has ordered 35 air dump cars from the Magor Car Corporation and 20 from the Differential Car Company.

The Wheeling Steel Corporation, West Va., is inquiring for 10 flat cars of 70-ton capacity.

The Texas Company has ordered 100 tank cars of 8,000 gal. capacity and 100 to 10,000 gal. capacity from the American Car & Foundry Company. The Oliver Iron Mining Company is inquiring for 25 to 50 air dump cars.

The Colorado & Southern Railway has ordered 100 ballast cars from the Rodger Ballast Car Company.

The Canadian National Railways has ordered 500 automobile box cars from the National Steel Car Corporation, 1,000 box cars of 60-ton capacity from the Canadian Car & Foundry Company and 200 refrigerator cars from the Eastern Car Company.

The Cities Service Tank Line Company, New York, N. Y. has ordered 50 tank cars of 10,000 gal. capacity from the General American Tank Car Corporation.

The Chicago & North Western Railway has ordered 500 hopper cars of 70-ton capacity from the Pressed Steel Car Company.

The Missouri Pacific Railroad has ordered 100 Hart convertible type ballast cars from the Rodger Ballast Car Company.

Passenger Cars

The Baltimore & Ohio Railroad has ordered 10, 70-Ft. combination baggage and mail cars with 15 ft. mail compartment and 5 combination baggage and mail cars with 30-ft. compartment from the American Car & Foundry Company.

The Atchison, Topeka & Santa Fe Railway has ordered 5 combination mail and baggage cars and 2 combination coaches, baggage and smoking cars from the Pullman Car & Manufacturing Corporation.

The Frankfort & Cincinnati Railway has ordered one gasoline rail motor car from the J. G. Brill Company, Philadelphia, Pa.

The Canadian National Railways has ordered 10 first class coaches from the National Steel Car Corporation.

The Santa Fe System has placed an order for 10 postal cars and 20 chair cars with the Pullman Car & Manufacturing Corporation.

The United Railways of Havana have ordered 8, 60-ft. gas-electric rail motor cars from the J. G. Brill Company, Philadelphia, Pa.

The Southern Pacific Company is inquiring for 20, 72-ft. coaches, 5, two-compartment 72-ft. coaches, 5, three-compartment 72-ft. coaches, 5, 72-ft. interurban coaches, 30, 70-ft. baggage cars, 5, 70-ft. baggage and mail cars, 5, baggage horse cars and 6 dining cars.

The Alaska Railroad has ordered one gas-electric rail motor car and one 51-ft. passenger trailer car from the J. G. Brill Company, Philadelphia, Pa.

The Chicago Milwaukee & St. Paul Railway has ordered 5 passenger baggage motor car bodies from the Standard Steel Car Company.

The Missouri Pacific Railroad has ordered 70 cars for passenger train service, including 7 dining cars and 3 cafe club cars.

The New York Rapid Transit Company is inquiring for 50 articulated unit comprising 150 subway steel car bodies.

The Long Island Railroad has ordered 10 combination passenger and baggage cars and 117 steel coaches with the American Car and Foundry Company.

The Atchison, Topeka & Santa Fe Railway has ordered 2 dining cars from the Pullman Car & Manufacturing Corporation.

The Norfolk & Western Railway has recently placed in service 43 new all-steel passenger train cars, built at the Haran plant of the Bethlehem Steel Company.

Building and Structures

The New York Central Railroad has awarded a contract for the construction of a car repair shop at Toledo, Ohio, to cost approximately $75,000.

The Chicago, Springfield & St. Louis Railroad contemplates the construction of a roundhouse and improvements to its yards at Springfield, Ill.

The Canadian Pacific Railway have prepared plans for the construction of a coaling station of 100-tons capacity at Poplar Point, Man., Canada.

The Chicago, Burlington & Quincy Railroad contemplates the construction of a storehouse at Sheridan, Wyoming, to cost approximately $40,000.

The Southern Pacific Company has under consideration the construction of hotel facilities on the Apache Trail in Arizona,

The Santa Fe System contemplate the contruction of repair shops at Phoenix, Ariz.

The Chicago, Milwaukee & St. Paul Railway has awarded a contract for the construction of a combined hotel and station at Gallatin Gateway, Mont., to cost approximately $200,000.

The Missouri Pacific Railroad has awarded a contract for the construction of a passenger station at San Juan, Texas, to replace the one destroyed by fire.

The Gulf, Colorado & Santa Fe Railway have prepared plans for the construction of a 115-ft. turntable at Brownwood, Texas.

The Southern Pacific Company has awarded a contract for the construction of a brick and steel terminal at New Orleans, La. The terminal will be 300-ft. long, will include an office building and will house temporary storage of fruit and vegetables and will cost approximately $100,000.

The Pennsylvania Railroad plans the construction of a two-story trainmen's dormitory at Hawthorne yard, Indianapolis, Ind. The building will be 100-ft. by 100 ft. and will cost approximately $40,000.

The Missouri Pacific Railroad has awarded a contract to the American Bridge Company for the fabrication and steel to be used in company's office building at St. Louis, Mo.

The New York Central Railroad have contracted for the fabrication and steel work required for a new office building at Park avenue and 46th street, New York City.

The Canadian National Railway has plans prepared for the construction of a passenger station at Edmonton, Alta., Canada.

The Southern Pacific Company has awarded a contract for the construction of a passenger station at Merced, Calif., to cost approximately $150,000.

The Missouri-Kansas-Texas Lines contemplate the construction of a storage building at Parsons, Kans., to cost approximately $40,000.

The Illinois Central Railroad has awarded a contract for the construction of a car repair shop facilities at Paducah, Ky., to cost approximately $200,000.

The Louisville & Nashville Railroad contemplates the construction of an office building at Latonia, Ky., and expansion of its yards at De Coursey, Ky., and Spring Lake, Ky.

The Missouri Pacific Railroad has awarded a contract for the construction of a one-story steel and concrete machine shop, 50-ft. by 126-ft. at Nevada, Mo.

The Elgin, Joliet & Eastern Railway contemplates the construction of a one-story brick dormitory at South Chicago, Ill., to cost approximately $25,000.

The Texas & Pacific Railway has plans prepared for the construction of a yard and engine terminal at Ft. Worth, Texas, to cost approximately $2,500,000.

The Louisville & Nashville Railroad has awarded a contract for the construction of a one-story brick and hollow tile passenger station at Edgewater Park, Miss.

The Central Vermont Railway has awarded a contract to Roberts & Schaefer Company, Chicago, Ill., for installing electric hoisting machinery at its coaling station at Burlington, Vt.

The Canadian Pacific Railway has awarded a contract for a 40-ton mechanical operating coaling station at Winnipeg, Man., Canada, also for a cinder pit at Kimberly, B. C., Canada.

Items of Personal Interest

O. P. Reese, superintendent of motive power of the Eastern Ohio division of the Pennsylvania Railroad with headquarters at Pittsburgh, has been appointed general superintendent of motive power of the Central region, with the same headquarters, succeeding **F. W. Hankins** who has been appointed chief of motive power.

T. W. Coe, has been promoted to superintendent of motive power of the New York, Chicago & St. Louis Railroad, he was formerly master mechanical superintendent of the Western region with headquarters at Youngstown, Ohio.

Taber Hamilton has been appointed general agent and superintendent of Grand Rapids division of the Western region of the Pennsylvania Railroad with headquarters at Grand Rapids, Mich.

O. C. Wright, road foreman of engines on the Western region of the Pennsylvania Railroad with headquarters at Indianapolis, Ind., has been promoted to master mechanic of the Indianapolis division with the same headquarters, succeeding **W. R. Davis.**

James J. Moynihan, has been appointed superintendent of transportation of the Erie Railroad with headquarters at New York, N. Y.

Henry H. Wilson, general road foreman of engines of the Boston & Maine Railroad with headquarters at Boston, Mass., has been appointed assistant to the mechanical superintendent, with the same headquarters. The position of general road foreman of engines has been abolished.

W. T. Abington, general foreman of the Missouri Pacific Railroad with headquarters at North Little Rock, Ark., has been appointed master mechanic of the Little Rock division with headquarters at McGhee, Ark., succeeding **A. R. Sykes,** transferred.

Charles James, mechanical superintendent of the Ohio region of the Erie Railroad with headquarters at Youngstown, Ohio, has been appointed mechanical superintendent of the Eastern district, with headquarters at Hornell, New York.

John W. McVey, research engineer of the Boston & Maine Railroad with headquarters at Boston, Mass., has been appointed supervisor of locomotive performance in charge of road foreman of engines with the same headquarters.

George H. Logan, general foreman of the Chicago shops of the Chicago & North Western Railway, has been appointed superintendent of locomotive shops at the same point, succeeding **J. Murfin,** retired.

D. C. Reid, master mechanic of the Indiana Harbor Belt Railroad with headquarters at Gibson, Ind., has been appointed assistant mechanical superintendent of the Boston & Maine Railroad with headquarters at Boston, Mass.

G. H. Kidder, superintendent of the Connecticut river division of the Boston & Maine Railroad has been appointed assistant general secretary of the roads' safety department, and **A. W. Perkins** has succeeded him as superintendent of the Connecticut river division.

M. E. Wilcox, foreman of inspectors of the Indiana Harbor Belt Railroad with headquarters at Gibson, Ind., has been appointed assistant superintendent car maintenance of the Boston & Maine Railroad with headquarters at Boston, Mass.

E. H. Roy, master mechanic of the Seaboard Air Line Railway has been appointed general master mechanic of the Western district with headquarters at Savannah, Ga.

Samuel Lynn, master car builder of the Pittsburgh & Lake Railroad with headquarters at McKees Rocks, Pa., has been appointed superintendent of rolling stock with the same headquarters. **W. C. Land,** assistant master car builder has been appointed master car builder succeeding **Samuel Lynn.**

Alva C. Elston, superintendent of transportation of the New York region of the Erie Railroad, with headquarters at Jersey City, New Jersey, has been appointed assistant to the resident vice-president.

H. Ballenberger, general foreman of the locomotive department of the Seaboard Air Line Railway with headquarters at Andrews, So. Car., has been appointed master mechanic of the East Carolina region with the same headquarters.

J. B. Diven, master mechanic of the Philadelphia Terminal division of the Pennsylania Railroad with headquarters at West Philadelphia has been appointed superintendent of motive power of the Eastern Ohio division with headquarters at Pittsburgh, succeeding **O. P. Reese.**

J. E. Reilly, has been promoted to superintendent of the Joliet division of the Elgin, Joliet & Eastern Railway with headquarters at Joliet, Illinois. Mr. Reilly was formerly trainmaster with the same headquarters.

H. McLendon, roundhouse foreman of the Seaboard Air Line Railway with headquarters at Monroe, N. C., has been appointed master mechanic with headquarters at Savannah, Ga., succeeding **E. H. Roy.**

William H. Simmons has been appointed general foreman of the Pittsburgh & Lake Erie Railroad with headquarters at Dickerson Run, Pa., succeeding **P. H. Fieldson**, promoted.

C. H. Venso has been appointed to boilermaker foreman of the Missouri Pacific Railroad with headquarters at Kingsville, Texas. **L. L. Taylor** has been appointed to assistant night roundhouse foreman with headquarters at Van Buren, Ark., **R. W. Humbert** has been appointed to night roundhouse foreman with headquarters at Mart, Texas, succeeding **J. J. Mooney.**

K. A. Lentz, erecting shop foreman of the Southern Railway with headquarters at Spencer, No. Car., has been promoted to shop superintendent with the same headquarters.

J. K. Morgan, general foreman of the Chicago, Rock Island & Pacific Railway, with headquarters at Little Rock, Ark., has been promoted to master mechanic with headquarters at Dalhart, Texas.

L. E. Delfraisse has been appointed car foreman of the Missouri Pacific Railroad, with headquarters at Mart, Texas.

A. E. Marsh has been appointed from the position of terminal trainmaster to that of superintendent of terminals of the Southern Railway with headquarters at Jacksonville, Fla.

A. T. Kinne, assistant manager of the Louisville & Nashville Railroad has been appointed to the position of roadmaster in charge of the Birmingham Mineral division, with headquarters at Birmingham, Ala.

James Paul, formerly assistant superintendent of motive power of the Atlantic Coast Line Railway, with headquarters at Tampa, Fla., has been promoted to the newly created position of superintendent of motive power at that point.

B. E. Widder has received appointment as engineer of buildings of the Atlantic Coast Line Railway with headquarters at Wilmington, N. C., succeeding **A. M. Griffin**, resigned.

L. A. Young has been appointed general foreman of the Missouri Pacific Railroad with headquarters at Atchison, Kans. **R. Morris** has been appointed general foreman with headquarters at Falls City, Nebr., and **J. M. Kilfayl** has been appointed shop foreman of the shops at Falls City, Nebr.

Phillip S. Shipman has been appointed boiler foreman of the Frisco Lines with headquarters at Chaffee, Mo., succeeding **M. L. Mitchell**, resigned.

John Nachbar has been appointed shop foreman at that point succeeding **W. P. Shean**, resigned.

A. W. Turner has been appointed master mechanic of the Michigan Central Railroad with headquarters at Niles, Mich., succeeding **J. T. Willis** promoted.

James Paul has been appointed superintendent of motive power of the Atlantic Coast Line Railway with headquarters at Tampa, Fla.

Charles S. Hogan has been appointed assistant master mechanic of the St. Cloud River Railroad, with headquarters at St. Cloud, Calif.

R. L. Clawson has been made general foreman of the Missouri Pacific Railroad with headquarters at De Quincy, La. and **E. E. Bruce** is appointed roundhouse foreman, and **C. Ackers** becomes mechanical foreman with headquarters at New Iberia, La.

Supply Trade Notes

Henry F. Gilg, formerly sales manager of the **Pennsylvania Iron and Steel Co.**, has been made general agent of the **Atlas Steel Corp.**, Dunkirk, N. Y., office at Pittsburgh, Pa.

G. M. Lawrence has been appointed sales manager of the **United States Electrical Tool Company.** Mr. Lawrence was formerly district manager with headquarters at Cleveland, Ohio.

Cecil R. Pilsbury, general auditor of the **Commonwealth Steel Company**, Granite City, Ill., has been promoted to treasurer. **O. T. Ledford**, assistant to the president has been promoted to secretary. **Frank L. Morey**, secretary and treasurer has resigned. **Harrison Hoblitzelle** has been elected vice-president and manager of purchases.

Harry Howe has been appointed engineer of railway equipment of the **Manganese Steel Forge Company**, Philadelphia, Pa. Mr. Howe resigned as special engineer for the **Pressed Steel Car Company.**

The Commonwealth Steel Company, Granite, City, Ill., is constructing a shop building 100 ft. by 600 ft. in area.

E. S. Black has been appointed consulting engineer of the **American Manganese Steel Company**, Chicago Heights, Ill., **A H. Exton** has been appointed chief engineer.

W. H. S. Baterman has been appointed district sales manager of the **Detroit Seamless Steel Tubes Company**, Detroit, Michigan, in charge of the southeastern district, with headquarters at Commercial Trust building, Philadelphia, Pa.

Joseph G. Worker has been appointed general sales manager and elected a director of the **American Engineering Company**, Philadelphia, Pa. For years Mr. Worker was associated with the **Westinghouse Companies** and for the last five years was manager of the stoker section of the **Westinghouse Electric & Manufacturing Company** with headquarters at East Pittsburgh, Pa.

W. P. Meigs has been placed in charge of the new office of the **Magor Car Corporation**, with headquarters at 133 W. Washington street, Chicago, Ill.

G. LaRue Masters, in charge of sales in the United States and Canada of the window equipment department of the **National Lock Washer Company**, Newark, New Jersey, has been appointed assistant general sales manager of the company.

Arthur Simonson, sales manager of the steel foundry department of the **Falk Corporation**, Milwaukee, Wisc., has been elected vice-president.

Edwin H. Peirce, Worcester, Mass., has been choosen vice-president of the **Niles Tool Works Company, Hamilton, Ohio.**

George M. Dyke has been made secretary of the **Stearns Conveyor Company**, Cleveland, Ohio, a subsidiary of the Chain Belt Company, Milwaukee, Wisc.

The Union Manufacturing Company, New Britain, Conn., has purchased and taken over the entire assets of the **Franklin-Moore Company**, of Winsted, Conn., who manufacture a complete line of hain hoists, blocks, trolleys, etc.

W. J. Savage railroad service engineer of the **Anchor Packing Company**, Chicago, Ill., has been promoted to assistant district manager.

The T. Z. Railway Equipment Company, Lytton building, Chicago, Ill., has been organized by **G. S. Turner**, president; **F. S. Zimmerman**, vice-president and **F. J. Kearney**, vice-president. Mr. Turner was formerly president of the **Viloco Railway Equipment Company**, vice-president of the **Okadee Company**, the **Charles R. Long, Jr. Company** and the **Viloco Machine Company.** Mr. Zimmerman was formerly vice-president and secretary of the Viloco Railway Equipment Company, Okadee Company, and assistant of the Charles R. Long, Jr., Company and secretary-treasurer of the Viloco Machine Company. Mr. Kearney was formerly mechanical expert for the same companies.

R. H. Bourne formerly vice-president and sales manager of the **Whiting Corporation**, Harvey, Ill., is now senior vice-president and will devote his entire time to the **Grindle Fuel Equipment Company** and **Joseph Harrington Company** sales. **N. S. Lawrence** formerly vice-president and assistant sales manager is now vice-president and sales manager in charge of the sales of **Whiting Corporation** and **Swenson Evaporator Company** lines. He will be assisted by **A. H. McDougall** vice-president and consulting engineer, and **R. E. Prussing** vice-president in charge of district offices and agents. The above changes in the sales organization were made on account of the addition of new lines.

The Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. has recently announced two important new appointments. **E. B. Newill** is made manager of the Control Engineering Department; and **H. D. James**, associated with the company becomes Consulting Control Engineer

Howard E. Oberg is now in charge of sales engineering in the Middle West for the complete machinery line of the **Billings & Spencer Company**, Hartford, Conn. Mr. Oberg's headquarters are in the General Motors building, Detroit, Mich.

H. O. K. Meister has been made general sales manager and **A. W. Scarrett**, chief engineer of the **Hyatt Roller Bearing Company**, Newark N. J., and **B. H. Lytle** is in charge of the Pittsburgh office.

The Clark Car Company, Pittsburgh, Pa., manufacturers of extension side dump cars, have opened a new sales office at Minneapolis Minn.

J. O. Dearth has been appointed district sales manager of the **Central Alloy Steel Corporation**, Massillon, Ohio, with headquarters at Cincinnati, Ohio.

Charles R. Long, Jr., president of the **Charles R. Long, Jr., Company** and vice-president of the **Viloco Railway Equipment Company**, Chicago, Ill., has been elected president of the latter company to succeed **G. S. Turner**, resigned.

The Pettibone Mulliken Company, Chicago, Ill. has purchased the **Interstate Railway Supply Company**, Cleveland, Ohio. **Albert Swartz** sales manager of the latter becomes associated with the former company in charge of sales.

Fred M. Barley is sales manager, and **H. T. Thompson** service manager of the **Graybar Electric Company**, with headquarters at Ft. Wayne, Ind.

Philip Robinson manager of sales of the **Gray Screw & Bolt Company**, Chicago, Ill., has been elected vice-president and general manager of sales.

The Transportation Equipment Corporation was recently organized, and will establish its office in the new Graybar building, New York City, about April 1. **Thomas J. Crowley** is president and **Chester B. McLaughlin, Jr.**, is vice-president and treasurer. The directors include **Colonel Douglas I. Mc-**

Kay, president of the **Standard Coupler Company.** Among the immediate activities of the Corporation will be efforts to increase in the railway field the use of Duco and other manufactures of the Chemical Products division of **E. I. duPont de Nemours Company.**

The Gisholt Machine Company, Madison, Wisc., recently opened an office at 722 West Washington Boulevard, Chicago, Ill. in charge of **R. E. MacCartney,** Mr. MacCartney will be assisted by **E. B. Verner.**

L. A. Quinn has been made manager of the Birmingham office of the **Niles-Bement Pond Company,** succeeding N. C. Walpole, deceased.

C. E. McGregor formerly representative of the **Republic Flow Meter Company,** Chicago, Ill., has been appointed representative of the **Brown Instrument Company,** Philadelphia, Pa. with headquarters at Chicago, Ill.

The Chambersburg Engineering Company, has opened office in the Stephenson building, Detroit, Mich. **R. Ripley** is manager in charge of that territory.

The Sharon tank car plant and the Beaumont Texas structural steel fabricating plant of the **Pennsylvania Car Company** were taken over by the **Petroleum Iron Works Company,** Sharon, Pa.

Curtis B. Friday has been appointed sales engineer of wheels and forgings in the rail bureau of the general sales department of the **Illinois Steel Company,** Chicago, Ill., **Norman M. Hench** has been appointed sales engineer of track accessories in the rail bureau of the general sales department.

Edward H. Mattingley formerly representative of the **Chicago-Cleveland Car Roofing Company,** Chicago, Ill., has been appointed representative of the **Bradford Corporation,** with headquarters at Chicago, Ill.

Obituary

Benjamin Nikolas Broido, Chief Engineer of the Industrial Department, of The Superheater Company, of New York and Chicago, died suddenly at his home in New York, Feb. 10, 1927. Mr. Broido was known throughout this country and abroad as a designer of exceptional ability of steam superheaters and heat exchange apparatus.

Mr. Broido was born in Wilna, Russia, in January, 1879. His early education was obtained in Germany, and he was graduated in 1904 from Frederick's Polytechnic, Gothen, Germany, with a degree in mechanical engineering. For the next two years he was an instructor at the Polytechnic.

From 1906 to 1912, Mr. Broido was connected with Ascherslebener Maschinenbau A. G., Aschersleben, Germany. Realizing that in order to design superheaters properly he must first be thoroughly familiar with stokers and boilers, he next became connected with Hannoversche Maschinenbau A. G., Hannover, Germany, where he developed a new design of Stirling boilers to better suit them to conditions in that country.

Mr. Broido came to this country in 1914 and took a postgraduate course in the City College of New York and Columbia University. Later he became connected with the Roessler and Hasslacher Chemical Company, Perth Amboy, N. J., for whom he designed power plants. In 1927 he was engaged by the Philadelphia and Reading Railway Company to design a power and creosoting plant. At the end of 1917 he became connected with The Superheater Company as designing engineer in charge of design and development of Elesco superheaters for stationary boilers.

As a member of the American Society of Mechanical Engineers, he took an active part in steam power plant work. He delivered the following papers at various meetings of the society. "High Temperature and High Pressure Steam Lines," "Radiation in Boiler Furnaces," and "Mechanical Engineering in the Cracking, Heating and Cooling of Oil."

In the past nine years, Mr. Broido has filed over 75 patent applications in this country and abroad for boilers, superheaters, economizers, heat exchangers, pipe stills, etc. He contributed a number of articles in engineering magazines on diverse subjects, of which some are as follows: Indirect Economizer, Results with Superheaters, European Experience with Stirling Boilers, Waste Gas Superheaters, What is Ahead in Power Plant Design, Superheat and Reheat, New Field for Desuperheaters.

In October, 1924, Mr. Broido addressed the Engineers' Society of Western Pennsylvania on the subject of "Recent Development in the Use of High Pressure and Superheated Steam." His last paper, entitled "Recent Development in Boiler Furnaces," was delivered before the Engineering Institute of Canada at a meeting in Montreal in January.

Mr. Broido was also a member of Verein Deutscher Ingenieure, the Engineers Club of Philadelphia and Raritan Lodge No. 61, F. & A. M.

H. H. Forney, formerly mechanical engineer of the Southern Pacific Company, died on February 4th at Hanover, Pa. He was born at Hanover, on October 28, 1869.

He served as machinist's apprentice on the Pittsburgh, Cincinnati, Chicago & St. Louis (now a part of the Pennsylvania), and from the latter date until September of the same year prepared to enter Ohio State University, where he remained from September, 1889, until January, 1893. From July, 1893, until September, was a machinist on the Southern Pacific at Sacramento, Cal. He then served as assistant to the engineer of tests until September of the following year. He was locomotive fireman at Summit, Cal., and then served as roundhouse foreman at Winnemucca, Nev., until September, 1896, until July, 1898, he was assistant master mechanic at Wadsworth, Nev., and then became general air brake inspector, which position he held until July, 1902. Mr. Forney then became master mechanic at Sacramento, Cal., where he remained until September, 1905. He was then appointed general air brake inspector, which position he held until August, 1915, when he was granted a leave of absence. From December, 1915, until November, 1925, he was mechanical engineer in the valuation department, and on November 1, 1925, was placed on the pension list of the Southern Pacific.

Justus H. Schwacke, former president of William Sellers & Co., Inc., Philadelphia, Pa., died on February 17 at Boca Grande, Florida, at the age of 79. Mr. Schwacke had served the company continuously from July 15, 1862, to May 31, 1926, when he resigned and retired to private life. He was elected secretary when the company was incorporated in 1886, director in 1902. He was active since their formation in a number of associations including the National Metal Trades Association, of which he was president for the year 1910-11, and served also for several years as president of the Metal Manufacturers Association of Philadelphia.

Arthur A. Stebbins, editor of the Boston & Maine Employees Magazine died suddenly on February 16, at his home in Brookline, Mass. Mr. Stebbins was formerly superintendent of the Montpelier & Well River and the Barre & Chelsea Railroad. He was then appointed as assistant secretary of the safety department of the Boston & Maine Railroad in 1918. In July, 1926 he assumed the editorship of the Employees magazine in addition to his duties in the safety department.

Frederick Beaumont Sheldon, vice-president of the Ohio Central lines of the New York Central Railroad with headquarters at Columbus, Ohio, died on March 1 of heart disease.

Colonel Charles De Lano Hine, well known in the railroad field for many years as an expert in transportation problems, died at the Roosevelt Hospital, New York City, on February 13 from complications following an operation.

He was born on March 15, 1867, at Vienna, Va., a suburb of Washington. He was graduated from the Washington, D. C., high school in 1865 and six years later was graduated from the United States Military Academy at West Point. He received also the degree of bachelor of laws from the Cincinnati Law School and in 1893, while serving as a lieutenant in the army, he was admitted to the bar. In 1895, however, he resigned his army commission to enter railroad service as a freight brakeman on the Cleveland, Cincinnati, Chicago & St. Louis Railway. In railroad service he worked as a brakeman, switchman, yard master, emergency conductor, chief clerk, train master, assistant superintendent, right-of-way agent, general superintendent, receiver, general manager and vice-president, besides holding various unique staff positions while doing special work for numerous railway and other corporations and for the United States government.

He served in the siege of Santiago de Cuba in the Spanish American War in 1898 as major in the United States volunteers. In 1900 he was inspector of safety appliances for the Interstate Commerce Commission. While with Gunn, Richards & Co. in 1907, he was receiver of the Washington, Arlington & Falls Church Electric Railway. From 1908 and 1911, he was employed as organization expert for the Union Pacific-Southern Pacific Systems (Harriman Lines), and during this period originated and installed the so-called unit system of organization. In 1912 and 1913, he served as vice-president and general manager o the Southern Pacific Railroad.

When the United States entered the World War he was placed in charge of the 69th New York regiment of the New York National Guard and other detachments, and which was later a part of the famous 42nd Division. Before his regiment left for France, however, he was transferred to General Pershing's Staff and was later a Colonel in the Motor Transport Corps.

Since 1921 he held a commission as a colonel in the Officers Reserve Corps. Immediately after his return from France, he was for a time chief of operation of the New York Citizens Transportation Committee at a time when labor troubles and related difficulties threatened to handicap the delivery of food supplies in that city, following which he resumed his work as a consulting railroad organization expert. In his more recent years among the companies for which he prepared studies were the New York, New Haven & Hartford, the Baltimore & Ohio, the Missouri Pacific, the International Business Machines Corporation, etc.

Colonel Hine was the author of "Letters from an Old Railway Official to His Son" first series published by the Railway Age in 1904, and the second series in 1911.

L. E. Osborne, mechanical engineer of the Locomotive Stoker Company, died on January 30, in the Bellevue Suburban Hospital, Pittsburgh, Pa., following an attack of pneumonia, at the age of 45 years. Mr. Osborne received his technical education at the George Peabody College, Nashville, Tenn., and the Virginia Polytechnic Institute. After he graduated from the latter school in 1906, he entered the service of the Norfolk and Western Railway and worked for three years in the mechanical department under J. A. Pilcher. In 1909 he joined the engineering staff of the Westinghouse Air Brake Company, where he assisted in the development of the Street mechanical stoker. When the Locomotive Stoker Company was formed in 1913 and located at Schenectady, New York, he was one of the original staff of employees, serving in the capacity of designing engineer. Upon the removal of the Company to Pittsburgh in 1916 he was appointed mechanical engineer.

New Publications

Books, Bulletins, Catalogues, Etc.

The Safety Appliance Laws.—The Interstate Commerce Commission, has issued a booklet, pocket size, with folding plates which contains the texts of the safety appliance laws, ash pan law, orders of the commission fixing safety appliance standards with folding plates illustrating these standards. Copies of the booklet may be obtained from the Government Printing Office, Washington, D. C. Price Fifty cents.

Traveling Engineers Proceeding.—The proceedings has just been issued by the Traveling Engineers Association, Cleveland, Ohio, by W. O. Thompson, secretary. It contains the reports of the thirty-fourth annual convention of the Association, held at Chicago, September 14, 15, 16 and 17, 1926. The contents of the book are arranged the same as that in preceding convention reports. The material contained is of interest to traveling engineers, road foremen of engines, and others in mechanical departments. A brief report of the subjects considered at each convention since 1893 is listed. The proceeding contains 171 pages, bound in cloth and the price is $1.50 per single copy.

Maintenance and Repairs Elesco Locomotive Superheaters.—The Superheater Company, 17 East 42nd Street, New York, N. Y., has issued a Spanish edition of its instruction book, installation, operation, maintenance and repairs of Elesco locomotive superheaters, which is a translation of the fourth American edition published in 1925, and has been prepared for distribution in Spanish-speaking countries using that type of superheater. Copies of the book may be obtained by addressing the Company.

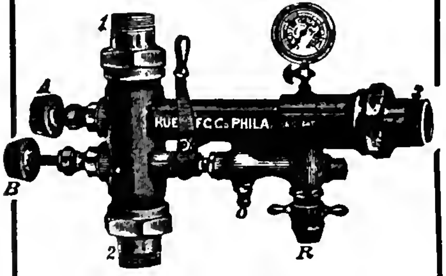
American Automatic Connector.—The Consolidated Connector Corporation, Cleveland, Ohio, has placed on the market a standard connector which has been found to function satisfactorily on all classes of equipment. The connector, which is fully described and illustrated in a booklet, is equipped with an adapter, making it unnecessary to uncouple air hose in interchange and eliminating the use of tools. Copies of the booklet may be obtained without charge by addressing the company at 118 Noble Court, Cleveland, Ohio.

New Torchweld Catalog.—The Torchweld Equipment Company, Chicago, Ill., manufacturers of oxy-acetylene welding and cutting equipment, have just issued a new 32 page catalog covering their complete line. The new catalog is of pocket size. The text of the catalog is condensed so as to give as nearly as possible a complete description of Torchweld line and at the same time have it convenient in size. Copies may be obtained by addressing the company at 224 North Carpenter St., Chicago, Illinois.

Arc Welder and Controller.—The Electric Welder Controller Company, Pittsburgh, Pa., has issued a bulletin on the Mann Master arc-welder and controller, which is well described and illustrated. Copies of the bulletin may be obtained from the Company.

Fundamentals of the Locomotive Machine Shop.—By Frank M. A'Hearn, assistant General Foreman of the Bessemer & Lake Erie Railroad. Published by the Simmons Boardman Publishing Company, New York City, N. Y. 250 pages, 111 illustrations, size 4⅝ by 7⅜. Price $2.50. This book is a most unique and useful treatise. It differs from the usual machinist's "handbook" in that it is intended for an entirely different purpose. It was designed to fill a long-felt need for a survey of locomotive shop-work to be used by apprentices, by those machinists who have worked on one machine so long that they have grown "rusty" on the others, as well as by officials and executives who are more or less out of touch with the shop themselves but nevertheless need a survey of them always at hand. All students, machinists, officials and executives of the shop development will derive much entertainment and interest from a perusal of the pages of this volume.

Nickel Steel.—The International Nickel Company, New York, N. Y., has issued Bulletin No. 9 showing the average values of tensile strength, elastic limit, reduction of area, elongation and Brinell hardness at various drawing temperatures are given for the S. A. E. standard nickel chromium steels is given. Copies may be obtained by addressing the company.



Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

Vol. XL 136 Liberty Street, New York, April, 1927 No. 4

The Reid-MacLeod Steam Turbine Geared Locomotive

A British Development in the Application of Turbines to a Locomotive

A recent development in the application of the steam turbine to a locomotive is that which has been constructed by the North British Locomotive Company, Ltd., under patents of Sir Hugh Reid and James MacLeod and is therefore the only turbine locomotive in existence that is entirely of British invention, design and construction. As will be observed from the accompanying illustrations, the arrangement consists of a long girder frame on which the boiler, condenser, water tank, cab, coal bunker, auxiliary machinery, etc., is mounted, and which is supported by two eight-wheeled trucks. Four wheels on each of the trucks are drivers. One truck is fitted with a high pressure steam turbine and the other with a low pressure turbine. These turbines drive through a reducing gear a short longitudinal countershaft which is provided at each end with a bevel pinion gearing with a large bevel wheel on a quill which, through the intermediary of a driving wheel drives the axle passing through it. No coupling rods being employed on the driving wheels a complete rotary motion and uniform torque is secured, and as a result a rapid acceleration is said to be obtainable and equal to that which can be secured with electric locomotives.

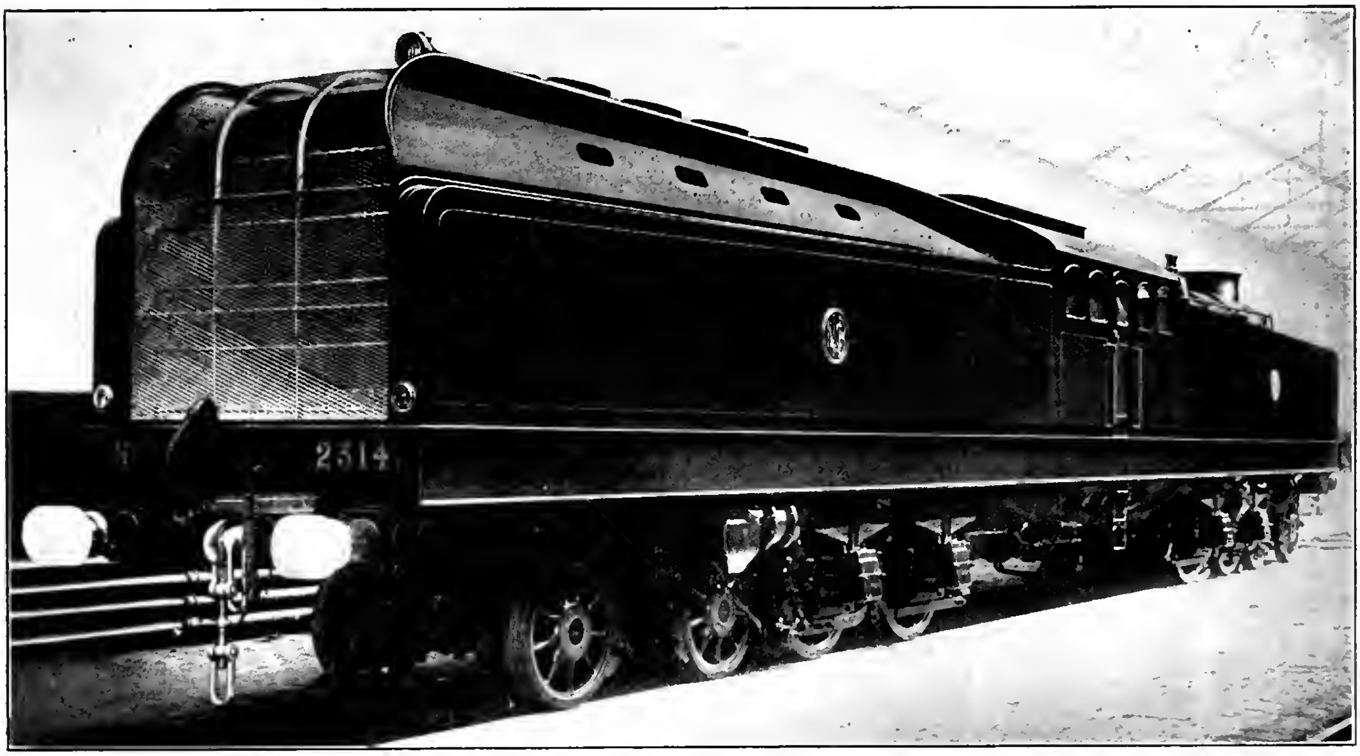


Fig. 1—Reid-MacLeod Steam Turbine Locomotive Built by the North British Locomotive Company

In Fig. 1 is shown a photographic view of the locomotive from the condenser or leading end and from which it will be seen that the stack is at the rear. Figs. 2 and 3 show the motive power mechanism of the low pressure and high pressure driving units respectively. Fig. 4 is a side view of the high pressure driving unit which shows the suspension and driving end of the quills, while Fig. 5 is a general view of the truck showing the four drivers and four additional carrying wheels.

The boiler is of the usual locomotive type with standard superheater and occupies the greater part of the rear end and below it is located the high pressure turbine truck. The steam exhausted from this turbine passes through either of two pipes, ahead or reverse, to the low pressure turbine which being right underneath, is able to deliver by a short path to the condenser. In substitution for the irregular blast of the reciprocating locomotive, a steady, forced or induced drafting system is provided. A fan driven by a steam turbine is employed, and arrangements are made to deliver the air from the fan into the ash pan at a pressure of about 4½ in. of water or to turn it up the chimney, so that an induced draft may be produced. The object of this arrangement is to prevent a blow-back of the flames on to the fireman when he opens the fire-door. The change from forced to induced draft is effected automatically. Over the end of the fire-door latch is fitted a small quadrant. This quadrant locks the door, which cannot be opened until it is lowered. Lowering the quadrant, shuts off the forced draft into the ash pan and opens a damper in the induced draft trunk. Thus the direction of the air is changed automatically, being always forced when the door is shut and induced when the door is open.

Steam from the boiler is delivered at a pressure of 180 lb. per square inch, through a control valve to the high-pressure turbine which is of the impulse type and the rotor of which is shown by Fig. 6. The low pressure turbine is also of the impulse type and is capable of developing 500 H. P. at 8,000 r.p.m., which corresponds to a running speed of 60 miles per hour. The low pressure turbine develops the same power and a reversing turbine giving 70 per cent of the power of the ahead turbine, is incorporated in each casing. On the left hand side of the cab there is a column near the summit of which a vertical hand wheel is mounted. By turning this wheel in the ahead or reverse direction, the engine is controlled both as to speed and direction. The ahead admission is effected through two 3 in. double beat valves, one of which opens after the other, both being used when full steam admission is required. A single 4 in. valve is employed for the reverse. The flow of the steam is shown in the diagram, Fig. 7.

The steam leaving the high pressure turbine passes through receiver pipes to the low pressure turbine, and thence to the condenser, which is of the air-cooled evaporative type. The condenser comprises groups of flattened copper tubes, cylindrical at both ends, where they are expanded into top and bottom tube plates, to which corresponding headers are fitted. The tubes are

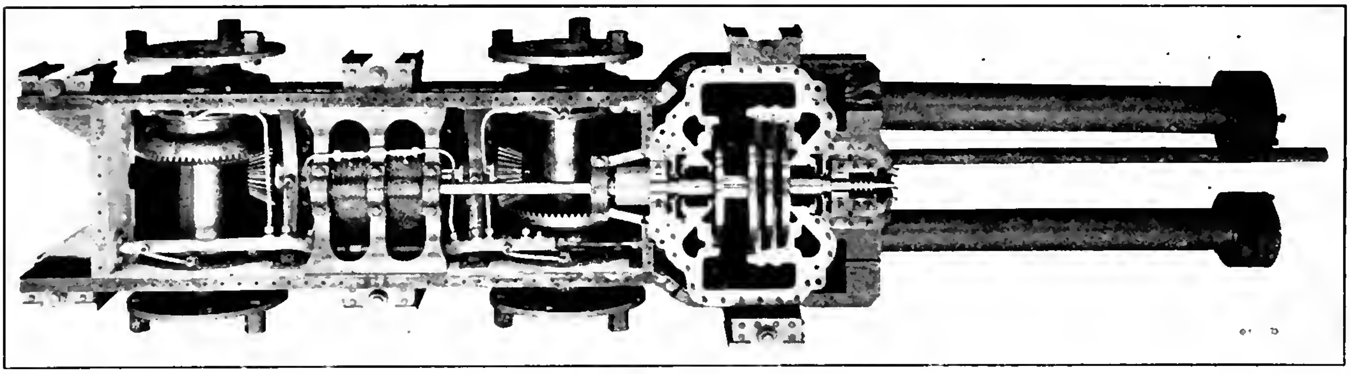


Fig. 2—Low-Pressure Mechanism Reid-MacLeod Turbine Locomotive

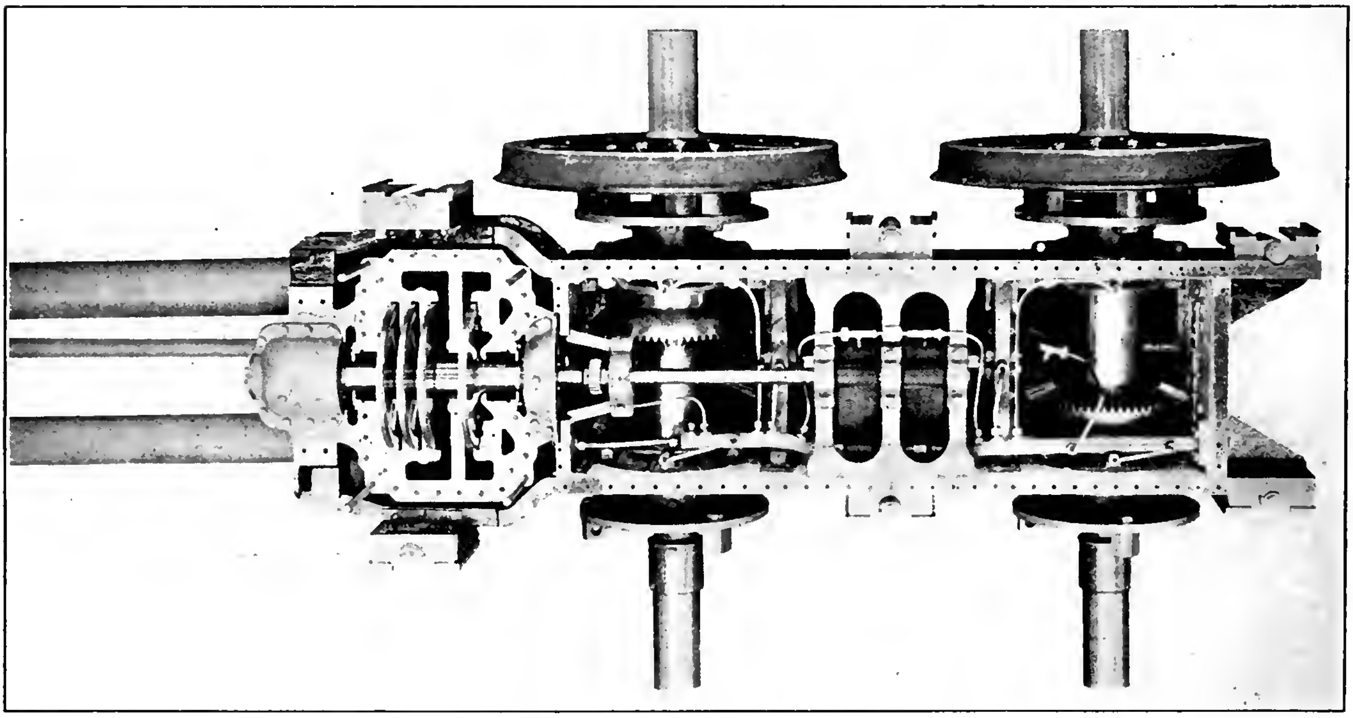


Fig. 3—High Pressure Mechanism Reid-MacLeod Turbine Locomotive

divided into two main groups, the exhaust ascending the tubes in the first group and descending those of the second group to the bottom header from which the condensate is withdrawn and discharged through the air pump intercooler to the hot well underneath the cab by a rotary pump. A turbine-driven fan draws air over the condenser tubes and at the same time water is delivered from a number of jets in a fine spray which settles on the tubes and is at once evaporated by the steam, the moisture-laden air being drawn out by the fan already mentioned and discharged to atmosphere. The jets or vaporizers, as they are called, are controlled from the cab by a control which indicates the particular group or groups of vaporizers in operation. Owing to the fact that the engine travels with the condenser leading, there is a natural current of air through it, which greatly assists the fan. The non-condensable gases are withdrawn from the condenser by a two stage steam ejector air pump, the heat in the steam being given to the condensate in an intercooler on its way to the hot well. As already stated, the condensate is withdrawn from the condenser by means of the condensate pump and discharged through the air pump intercooler to the hot well tank from which it is withdrawn by the boiler feed pump and delivered to the boiler through a feed-water heater, which receives it supply of exhaust steam from boiler feed, forced lubrication and Westinghouse pumps. The heater drains are returned to the hot well tank.

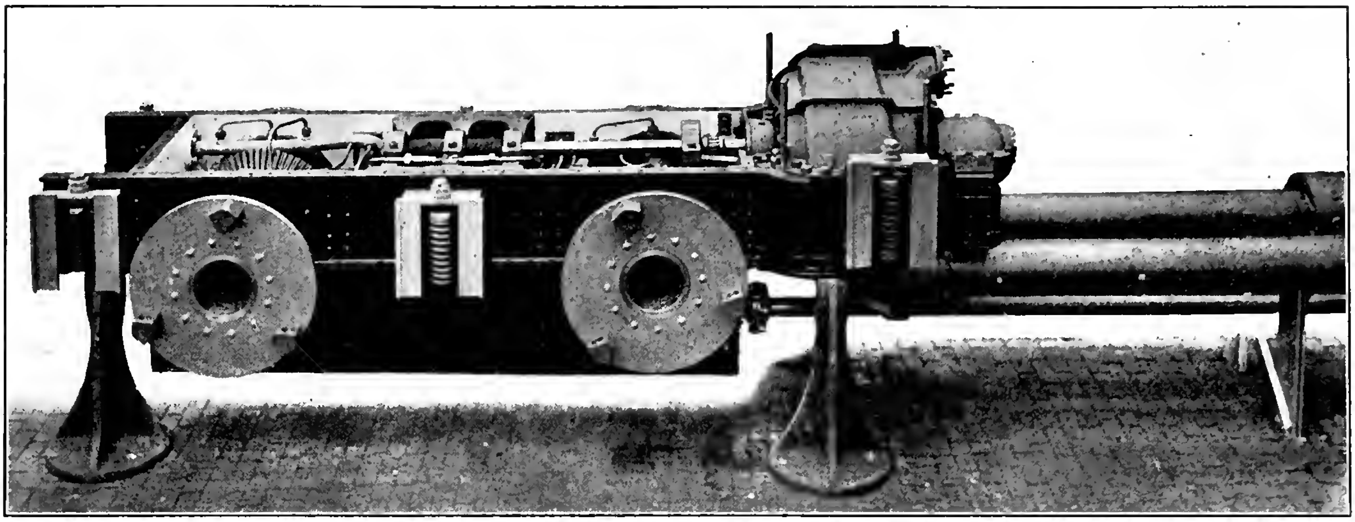


Fig. 4—Side View of High-Pressure Driving Unit

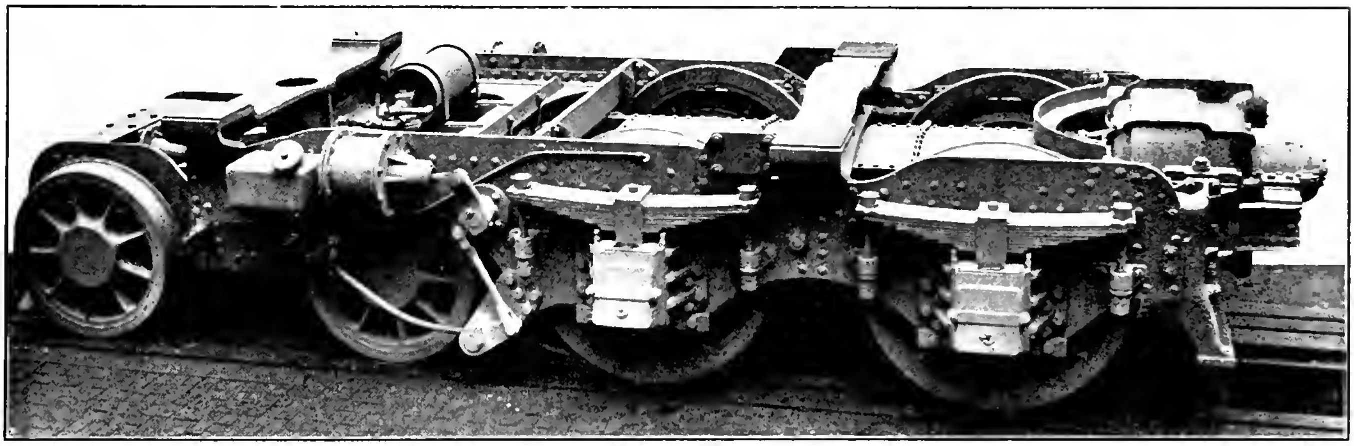


Fig. 5—General View of the High-Pressure Driving Truck

Again referring to the running gear of the engine, it will be seen that the high-speed pinion shaft in each case is provided with two helical pinions of opposite hand, which drive corresponding helical wheels. This arrangement, by providing four bearings, gives admirable support for the relatively light pinion shaft, which is flexibly connected to the turbine shaft, as indicated in Fig. 8. The reduction effected in this gear is 8 to 1. On each end of the countershaft a bevel pinion is keyed, and as one pinion gears with a bevel wheel on the right of the engine and the other with a bevel wheel on the left of the engine, both of the latter have the same direction of rotation. The reduction ratio in these pairs is 2.38 to 1, so that the total reduction is approximately 19 to 1. The bevel wheels are keyed to quills, which are provided at each end with discs on which three blocks are bolted. The axles pass through the quills and the wheels are driven in either direction through the intermediary of three helical springs in compression, spherically seated in the blocks already mentioned and corresponding projections on each wheel. The whole of the gearing is enclosed in oil-tight casings. On reference to Fig. 4, it will be seen that the whole motive power unit is carried on six helical springs, three on each side, and arranged within guides. Thus the main driving machinery as a unit is flexibly controlled in a floating position free from displacement of the surrounding structure and wheels of the locomotive.

A continuous cooled stream of lubrication is supplied

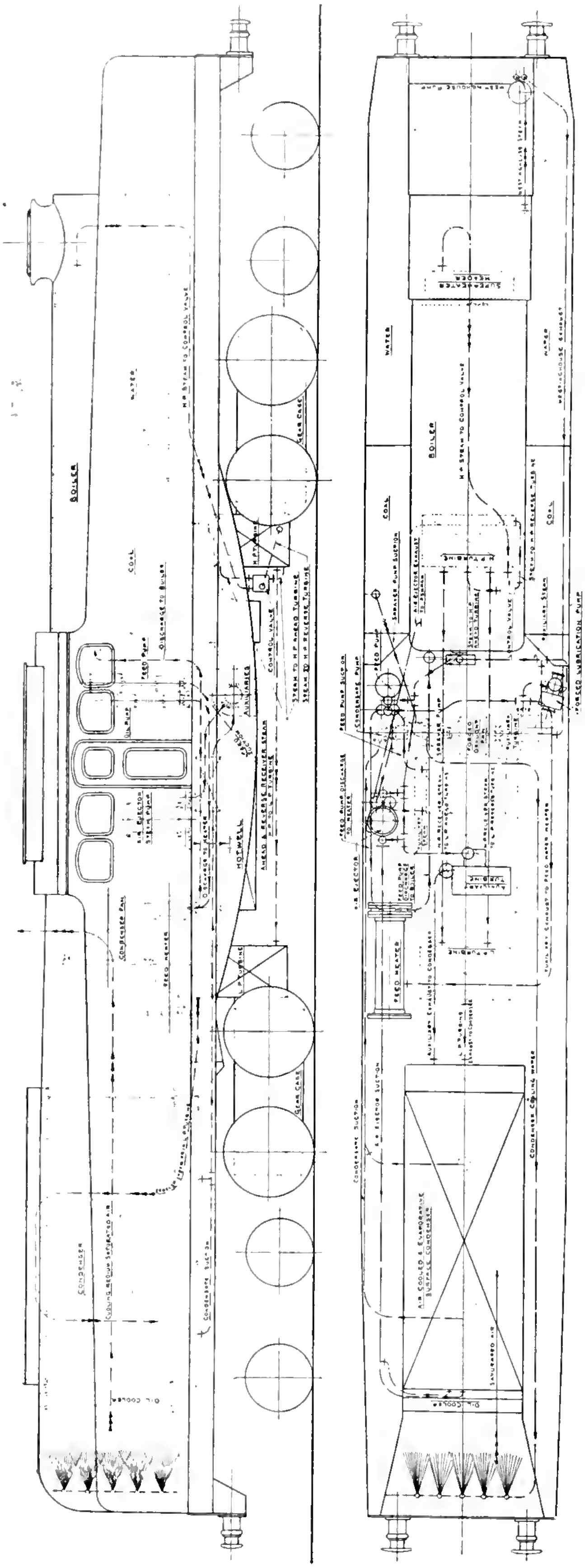


Fig. 7—Diagram Showing Flow of Steam, Water and Air Reid-MacLeod Turbine Locomotive

to all bearings and rotating parts of both main and auxiliary machinery, with the exception of the axle-boxes, by a steam-driven reciprocating pump.

The cab, is extremely roomy capable of accommodating eight or nine people and provides ideal conditions for the operating crew in which to perform their duties. At the fireman's end there are all the usual adjuncts of a normal locomotive boiler with, on the left of the engine, a vertical lubricating pump, steam driven, and on the right, a vertical steam feed pump.

We are indebted to Sir Hugh Reid of the North British locomotive Company for the details and photographs of the locomotive. The builders describe the sequence of operation of the machine when starting up as follows:

(1) Raise steam on boiler to 90 lb.

(2) Start up forced lubrication pump.

(3) Start up auxiliaries, turbine, driving, forced draught fan, condensate and condenser water sprayer pumps, which now enables the steam in the boiler to be rapidly raised to the working pressure.

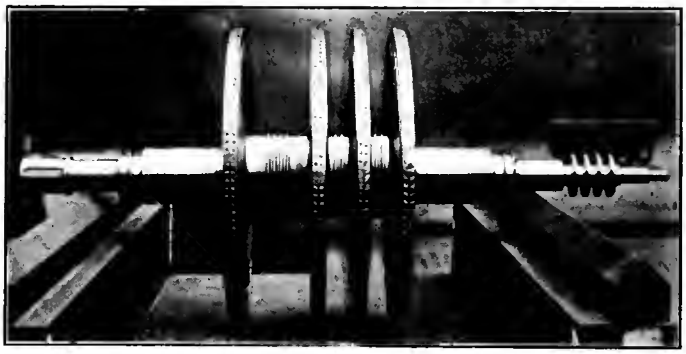


Fig. 6—Rotor of High-Pressure Turbine Reid-MacLeod Locomotive

(4) Open main steam boiler stop valve, which enables the saturated steam from the boiler to pass through the superheater to the main turbine control valves.

(5) Operate control valves, both ahead and reverse, passing steam through the main turbines for warming up.

(6) Open steam stop valve to second stage. Air ejector pump.

(7) Close main and auxiliary drains and open stop valves supplying steam to turbine glands, the vacuum in the main condenser will now register up to 20 in.

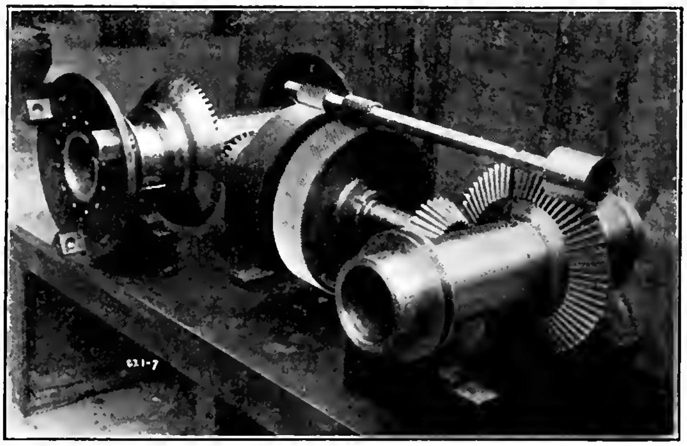


Fig. 8—Double Reduction Gearing With Quill-Drive Hollow Shafts

(8) Start up condenser air circulating fan turbine.

(9) Open steam stop valve to first stage air ejector pump, when the vacuum in the main condenser will register 28 in.

The locomotive is now in readiness for service.

The time taken to complete the cycle of operations after the steam has been raised is 7 minutes.

In passenger train service, it is estimated that the engine should haul 225 tons behind the tender at a speed of 60 miles per hour. The condensing water should amount to about 13 gallons per minute and the boiler feed to make up to half a gallon per minute. The tractive power of the engine as indicated from a dynamometer at the works of the builders is about 15,000 lb.

Taken as a whole it is the simplest form of turbine locomotive that has been built in recent years. The builders are to be congratulated for the research and heavy expenditure that must have been involved in this effort to improve the thermal efficiency and mechanical improvement in the locomotive as at present operating the traffic on railways.

An Early Locomotive Having a Leading Truck

By J. Snowden Bell

The four-wheeled swiveling truck, inappropriately termed, in England, a "bogie," is unquestionably one of the most important and valuable improvements that has ever been made in locomotive construction, and, while its adoption by builders, in foreign countries, was long delayed, it has now become as fully standard in their practice as it is in this country, in which it originated. In the first applications of it that were made, the two axles were located close together, and the truck had a swivelling movement only, relatively to the main frame of the locomotive. In the course of its development, it has been substantially improved by the addition of lateral motion appliances; the axles have been spread sufficiently far apart to allow horizontal cylinders to be located between them; and numerous features of structural improvement and details have brought it to its present high state of perfection.

The credit of the original design, and first application, of the swivelling truck, has been generally awarded to John B. Jervis, he having prepared a plan for it in the fall of 1831, and caused it to be applied on a locomotive which was built by the West Point Foundry Association, and placed on the track of the Mohawk & Hudson Railway in the summer of 1832. (*"Railway Property,"* by John B. Jervis, Philadelphia, 1866, pp. 159, 160.) The writer has not been able to find any record of the application of a truck in a locomotive which antedates that of John B. Jervis, above noted, and concurs in the general acceptance of his claim to originality of the design.

It may, however, be of interest to record the fact that another and entirely independent application of a four wheel leading truck was made on the locomotive "Herald," which was built by Stephenson, of England, for the then Baltimore & Susquehanna Railroad, now the Northern Central Railway, and put in service at some date prior to 1833. As originally constructed, this engine had one driving axle, and one bearing axle. The latter was removed after it had been demonstrated that the engine would not operate satisfactorily on the short curves of the road, and a four wheel swivelling truck was substituted, which overcame this objection. The only information obtained as to the truck on the "Herald" is that contained in the following excerpt from a book entitled "A Complete View of Baltimore," by Charles Varle, Baltimore, 1833 (p. 107):

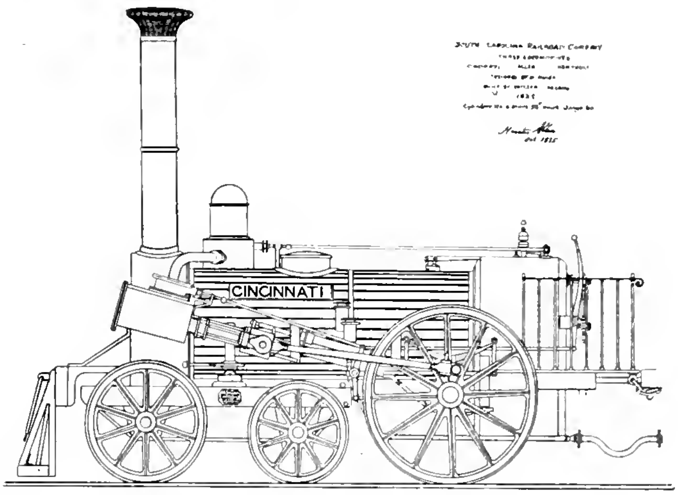
"In addition to what has been said of this road, on page 75, we will add, that the locomotive engine called the Herald, received last summer from Liverpool, which is a beautiful piece of mechanism, costing the company $4,000, being calculated to run on a straight track, would not suit this meandering road, but American genius overcame this difficulty, and the company, as well as the world, are indebted for this improvement to Mr. *Jonathan Knight,* of this city."

In the paragraph of Errata following page 1 of the volume, there appears the item: "Page 107 in Note for Jonathan Knight, read, J. Smith Hollins.

In view of the date of the publication being 1833, it is not determinable whether the words "last summer" refer to the summer of that year, or that of 1832 or 1831. If the last stated year is meant, there may be a question as to whether the truck of Jarvis' "Brother Jonathan," or that of the Baltimore and Susquehanna "Herald" is the earlier in date.

The locomotive "E. L. Miller," which was built by M. W. Baldwin, for the South Carolina R. R., in 1834, was equipped with a four wheel swivelling truck, the operation of which was so satisfactory that three more locomotives, fitted with this appliance, were ordered by the road from Tayleur & Co., of the Vulcan Foundry, Warrington, England, and put in service in 1835. These are represented in the accompanying illustration of the "Cincinnati," one of these engines, which is reproduced from a print bearing the following notation:

"South Carolina Railroad
Three Locomotives
Cincinnati Allen Kentucky
Designed by H. Allen
Built by Tayleur, England
1835
Cylinders 10 x 16 Drivers 54" Track gauge 60" "



Locomotive Cincinnati of the South Carolina Railway Built in 1835

The above notation bears the *autograph* "Horatio Allen, Oct. 1835," and the three locomotives are listed in the government *Report to the Secretary of the Treasury on Steam Engines.* Doc. No. 31, dated January 16, 1839, p. 262. The Report gives only the names of the engines; their "power in horses, 12"; and their then period of service, which, in the case of the "Cincinnati" was "about one-fifth of the time," of the "Allen," was "about one-fourth of the time," and of the "Kentucky," "about one-fifth of the time."

The structural details of the truck do not appear in the illustration, and are of no particular importance, as the perfected development of present standard practice has but little in common with them, and the South Carolina R. R. equipment which is illustrated, is of interest merely from a historical standpoint.

Anti-Friction Bearings on Railway Equipment

Extensive Application and Their Record on Foreign Railways

By W. E. Symons

The recent application of roller bearings to some of the equipment of railways in the United States which has been described in previous issues of this publication has attracted wide interest on the part of railroad men to this important development.

The impression prevails even among some of the more prominent railway engineers that this is entirely a new development still largely in the experimental stage, and while this is true of the situation in this country, as a matter of fact numerous kinds or types of ball and roller bearings have been applied to all classes of rolling equipment abroad where the subject is anything but in the early stages of experimentation or development. Much progress has been made in Sweden, Germany, Denmark and elsewhere in this direction. As a result of service tests of such equipment in Germany there seems to be no doubt that standardization will follow in the near future.

In collecting data on this subject it has been found that a leading manufacturer of these devices has them installed on locomotives, passenger and freight cars of railways in nineteen different countries as shown in the accompanying tables, and there are other manufacturers of anti-friction bearings whose designs are in use in this and foreign countries.

Country	Date and number			Axle load tons			Class
	First	Last	boxes	Pass.	Frt.	Loco.	
Australia	1922	1922	4	....	5.	..	4 Pass.
Austria	1924	1926	36	5.	....	2.6	16 Tenders 20 Pass.
Czecho-Slov.	1923	1926	246	5.5	5.5	..	238 Pass. 8 Frt.
Denmark	1922	1926	1,209	2.5-5.5	5.5	..	1147 Pass., 62 Frt.
Egypt	1923	1923	10	3.-6.	....	..	10 Pass.
England	1922	....	114	4.	....	..	114 Pass.
Finland	1923	1924	132	1.2-5.5	1.2	..	115 Pass., 16 Frt.
France	1923	1923	264	4.5-7	....	..	264 Pass.
Germany	1921	1926	1,608	4.-7.5	7.2-7.5	..	1422 Pass., 186 Frt.
Greece	1925	....	50	3.5	....	..	50 Pass.
Hungary	1924	1926	84	4.5-5.5	3.8	..	80 Pass., 4 Frt.
Italy	1924	....	80	5.5	....	..	80 Pass.
Japan	1923	....	12	4.	....	..	12 Pass.
Mexico	1922	1925	12	1.8-7.5	....	..	12 Pass.
Norway	1924	....	8	3.5	....	..	8 Pass.
Sweden	1921	1926	6,030	1.5-6.2	7.5 9	..	2736 Pass., 3294 Frt.
Switzerland	1924	1926	20	4.5-6.5	....	..	20 Pass.
Peru	1921	....	32	....	2.	..	32 Frt.
United States	1921	1926	1,498	7.5	....	..	1498 Pass.
Total............			11,449				

It will be observed that the installations are wide in their application including locomotive, tenders and leading trucks, passenger and freight cars, and that quite a number have been in use since 1921 and 1922, and that while the number in the United States made by this company is not as great as in foreign countries, no one of our most prominent trunk lines they have been in regular service since 1921.

The axle load in tons it will be observed ranges from as low as 1.2 tons in England to as high as 7.5 tons in Germany, Mexico and the United States.

A sub-division of the foregoing installations by class or kind of equipment is as follows:

Passenger stock	7,831
Freight stock	3,602
Locomotive tenders	16
Total	11,449

After years of experiments the S. K. F. evolved the spherical roller bearing — capable of taking more radial load than any bearing of its size, and in addition to the radial load able to deal with thrust loads up to 40% of its radial load carrying capacity. This bearing was first tried out on the Swedish State Railways and the results were so favorable that these railways decided to adopt the S. K. F. design for all their new equipment.

Importance of "Bearings" Investigation Work

The German Federal railroads operate approximately 800,000 rail vehicles. It is estimated that the use of the ordinary type of bearing leads to almost 250,000 hot boxes annually, so that nearly every third car burns a bearing, once a year. The replacement cost of the bearing alone is approximately 10 marks each, which places an annual burden of 2.5 million marks on the railroads for replacement of the bearings alone. This is aside from the frequently necessary replacement of axles which have become burned.

The average idle time of a car with a hot box amounts to 3 days, so that 750,000 car days are lost annually. To this must be added the great losses through disturbances of train schedules, etc., etc.

During the war, the German railroads were unable to purchase the proper lubricating oils and also faced serious difficulties in obtaining the necessary bearing metal consisting of 85% tin, which was not available in Germany.

Early Experiments in Germany

In 1903, the first experiments were made with 6 axles on passenger cars which were equipped with ball bearings from the Deutsche Waffen-und Munitionsfabriken, Berlin. These were subsequently replaced with the development of better roller bearings. Despite the antiquated construction and many obvious deficiencies the cars operated quite satisfactorily.

The greatest difficulty with the ball bearings, which was also encountered in later experiments in the United States, Sweden and Great Britain, was principally because of the small diameter of the balls and the fact that they were not able to withstand the constant hammer inflicted on them by irregularities of the track and rail joints.

In 1904, the Railroad Administration of Stuttgart equipped a passenger car with two DWF ball bearings which were still in active service in 1924.

The first experiments with roller bearings were made in 1909 with the Moffet roller bearing, and one of the cars is still in active service.

Special Bearing Investigation Department

The Federal railroads therefore organized a special bearing investigation department at the repair shops in Goettingen, to make careful experiments with the ordinary type of bearing, and to investigate their deficiencies.

The introduction of 50 ton, 4 axle freight cars on the German railroads with the consequent increase of wheel pressure from 7.5 to 10 metric tons, aggravated the problem. In 1922, therefore, the Federal railroads gave orders for an investigation of the possibility of adopting ball and roller bearings for railroad work to replace the old type of bearings.

The first experiments were to be conducted with a freight car train of 20 metric ton cars, which were equipped with a number of different bearings. The occupation of the Ruhr in 1923 prevented the building of these special freight cars, and they are to be completed in 1927.

In the meantime, however, the German Federal Railways have been conducting experiments with some other 50 and 20 ton freight cars equipped with different ball bearings manufactured by the following producers:

No. (1) Schweinfurter Praezisions-Kugellager-Werke Fichtel & Sachs Aktiengesellschaft, Schweinfurt/Main.
No. (2) Deutsche Gusstahlkugel-und Maschinenfabrik Aktien-Gesellschaft vormals Fries & Hoepflinger, Schweinfurt.
No. (3) S. K. F.-Norma G. m. b. H. Berlin W. 8.
No. (4) G. & J. Jaeger Aktiengesellschaft, Elberfeld.
No. (5) Fried. Krupp Aktiengesellschaft, Essen, Ruhr.
No. (6) Riebe-Werke Aktiengesellschaft, Berlin-Weissensee.
No. (7) Berlin-Karlsruher Industriewerke Aktiengesellschaft frusher Deutsche Waffen-und Munitionsfabriken, Kugellager - Werke, Berlin - Borsigwalde.

Experiments with 20-Ton Freight Cars

The 20-ton freight cars were equipped with the following bearings:

a—One row ball bearings, manufacturer (No. 1);
b—one row roller bearings, manufacturer (No. 4);
c—combined roller and ball bearings, manufacturer (No. 7).
d—combined spherical and cylindrical roller bearings, manufacturer (No. 3).
e—two row cylindrical roller bearings; manufacturer (No. 3).

Experiments with 50-Ton Freight Cars

Of these, 20 have been built. To enable the railways to make a satisfactory comparison, the same type of cars equipped with ordinary poured or bushing type bearings, manufactured by the Linke-Hofmann Werke, Breslau, and the Oberschlesische Eisenbahnbedarfs-Aktiengesellschaft, Gleiwitz, were run in the same experimental trains together with these cars which were equipped with ball and roller bearings.

The following bearings were used:

a—One row ball bearings, manufacturer (No. 1).
b—combined spherical and cylindrical roller bearings, manufacturer (No. 3);
c—spherical pendulum type roller bearings, manufacturer (No. 3).
d—one row collar roller bearings, manufacturer (No. 4).
e—one row roller bearings with side collar, manufacturer (No. 5).
f—two row cylindrical roller bearings, manufacturer (No. 6).

Roller Bearings on Electric Locomotives

Experiments have been conducted on the electrified local tracks of the Hamburg municipal railroads and on the Berlin suburban tracks Berlin-Oranienburg and Berlin-Bernau.

In Hamburg, 5 electric locomotives were equipped with one-row collar roller bearings, of manufacturer (No. 4). A number of locomotives were also equipped with combined spherical and cylindrical roller bearings, manufacturer (No. 3).

In Berlin, experiments are being conducted with:

a—combined spherical and cylindrical roller bearings, manufacturer (No. 3).
75 electric locomotives and passenger cars have been equipped with this type.
b—two row cylindrical roller bearings, manufacturer (No. 6), which have been installed on a total of 10 cars.

In Hannover, two old storage battery driven freight yard switching locomotives were equipped in 1923 with collar roller bearings of manufacturer (No. 7). They have been operating with good results, and in 1925 3 other electric freight yard locomotives have also been equipped with these bearings to replace the ordinary type.

There is also one storage battery driven freight yard switching locomotive operating satisfactorily on "Moffet" roller bearings since 1911.

Five tenders of the railways in Frankfurt have been equipped with a special type collar roller bearing of manufacturer (No. 7), and are operating satisfactorily.

On the basis of the experiments conducted in Goettingen, 16 technical specifications have been developed. So far, final recommendations have not been made. The laboratories in Goettingen are still conducting their investigations and do not expect to make final recommendations for some time. Special testing stands have been built for determining the bearing friction coefficient; measurements are made of the work performed by the bearings; the temperature and the consumption of energy at different speeds. Further tests are made to determine the starting inertia on each axle, each car, complete train, and other pertinent data.

The final goal towards which the work is being conducted is summed up as follows:

1—*Operation*
Safety of operation.
Elimination of hot boxes.
Saving of energy.
Saving of oil.
Saving of labor.
Three years' continuous operation without lubrication.

2—*Construction*
Interchangeability of wheel-sets with their bearings in the two following sizes:
Ball or roller bearings with 10 ton standing axle pressure and a speed of 60 kilometers per hour for freight cars.
Ball or roller bearings with 8 ton standing axle pressure and a speed of 120 kilometers per hour, to be used especially for passenger and Pullman cars.
The development of a one model standard bearing which can be applied for all types of work.

The application of ball and roller bearings for railroad work in Germany will be limited for the present, to either especially valuable cars where idle hours would mean a great loss to the railroads, such as large size freight cars, sleepers and Pullman cars, or to such passenger cars as are in continuous operation over the larger part of each day. A special field of application is also expected on local and suburban railroads where the cars not only perform a long mileage each day but where the trains must stop and start frequently, due to the short distance between stations. For this type of work ball or roller bearings are especially suited due to the low friction resistance at starting.

A number of difficulties were encountered in the preliminary investigations which cannot here be explained in detail. They may be summed up as lack of adequate springs, excessive shocks through rail joints and switches, horizontal thrust forces on the curve, and the small space available.

Test with SKF Axle Boxes on the Railway Paris-Orleans

Very extensive tests have been carried out on the French railways with SKF axle boxes for passenger coaches. The tests have been carried out only on passenger coaches for the reason that; first of all, it is considerably easier to follow these cars and make observations with them than is the case with freight cars; and in addition to this, the purchase price for the boxes in relation to the cost of a passenger coach is not so large as in relation to the cost of a freight car; and in conclusion it was expected that a saving in the pulling force would principally be found in repeated starts. For these reasons the intention was at first to mount roller bearings in coaches for local traffic. Three of the four railway firms agreed to this proposition and decided on such tests. Chemin de Fer du Nord equipped 6 large 50 ton bogie coaches, Chemin de Fer de l'Est preferred to use 20 local traffic coaches of an old type, Chemin de Fer d'Orléans selected 20 2-axle ordinary coaches and Chemin de Fer P. L. M. equipped 8 3-axle coaches.

All these coaches are of different types and all gave very good results so far as the roller bearings were concerned. The most interesting tests thus far have been carried out in Chemin de Fer d'Orléans where the intention has been to measure scientifically the saving in pulling forces that it would be possible to reach at various speeds.

The trial trains on Chemin de Fer d'Orléans were arranged according to a plan made up by Compagnie des Chemin de Fer P. L. M., which makes it possible to test plain bearing coaches and roller bearing coaches at the same time and under similar conditions. A dynamometer coach was placed after the locomotive and after this coach there were 8 plain bearing coaches; after these coaches there was another dynamometer coach and then 8 roller bearing coaches. After one trial run had been finished, the order of the various parts of the train was reversed in order to make the test as comprehensive as possible. The use of dynamometer coaches made it possible to register the pulling force and the positive work performed was integrated by automatic planimeters. In the calculation of diagrams, corrections were made for the work ensuing when the brakes are applied. This work is of great importance in trains used for local traffic because they stop so often. When the brake work is included in the calculation, it is possible to reverse the entire result first registered. This was already observed the first test day when the counting mechanism of the planimeters showed no economy whatever in the pulling force in favor of the roller bearings, whereas in the computation of the positive as well as the negative work it was possible to find a saving of 10.51 per cent when the train went out with the SKF coaches in the beginning of the train, and 7.66 per cent during the return trip when the SKF coaches were at the end of the train. The favorable influence exercised by the bearings in starting heavy trains was not particularly noticeable because the powerful locomotives which were used were sufficiently strong to start the trial train in a very short time.

Moreover, better results were obtained at the tests which were made with the direct trains after the local trains had been tested. Trial runs with 6 direct trains between Paris and Juvisy, a distance of 20 kilometers, where the average speed was 50 milometers per hour, showed successively the following savings:

The SKF coaches in front	The SKF coaches behind
20.39%	15.78%
22.82%	20.00%
24.77%	20.27%

Thus the average is 20.67 per cent for these particularly favorable trains; but it should be pointed out that all of the trial runs on Chemin de Fer d'Orléans were carried out with empty coaches, the inertia of which is of course less than the inertia of coaches full of passengers.

The reduction of the saving in pulling force which ensued when the SKF coaches were moved from their place in the beginning of the train to the end of it, has been explained in such a way that the suction which is created at the end of the train, when this is running, would be of greater importance than the air pressure which at the front of the train acts as an obstacle to the motion. The tests have, however, not contributed to throw any light upon this matter.

At a third series of tests the above-mentioned train was run four times between Paris and Tours, a distance of 250 milometers. The distance was divided into sections which were made as long as possible and on which it was tried to keep a constant speed: thus a series of speeds were obtained between 30 and 110 kilometers per hour.

At high speeds the economy is less than at low speeds owing to the resistance of the air.

In any case, one should try to avoid confounding the saving in pulling force dealt with above with the saving in the energy developed by the locomotive. As a matter of fact, the locomotive consumes for its own propulsion a considerable quantity of fuel; it might be said that at average speed, one-half of the coal burned is consumed in keeping the locomotive in motion and the other half for hauling the coaches. Thus a reduction of 15 per cent of the resistance of the coaches would mean an economy of from 7 to 8 per cent of the coal consumed.

In electrically driven trains the economy should be still higher, inasmuch as no more power is required to drive a motor coach than an ordinary coach.

It is expected that these tests will be continued and extended or amplified in the future by such study, trial and experimentation as will result in definite values for all factors embraced in the subject. Particular study should be made of the rolling friction per ton of weight at starting and at all rates of speed, and also the element of air pressure or suction under all operating conditions and rates of speed.

Equipment Installed in January and February

Class I railroads of this country in the first two months this year installed 305 locomotives, the Car Service Division of the American Railway Association announces.

This was a decrease of 61 locomotives under the number installed during the corresponding period in 1926 but an increase of 13 over the number installed during the corresponding period in 1925. Of the total number installed so far this year, 160 were placed in service in February.

Locomotives on order on March 1 this year totaled 276 compared with 441 on the same date in 1926 and 293 on the same date in 1925.

Freight cars installed in service the first two months this year totaled 10,621, a decrease of 2,196 under the corresponding period in 1926 and a decrease of 17,499 under the corresponding period in 1925. Freight cars installed in February this year totaled 5,137, including 1,27 box cars, 1,689 coal cars and 1,019 refrigerator cars.

Class I railroads on March 1 had 29,395 freight cars on order compared with 50,947 on the same date in 1926 and 50,629 on the same date in 1925.

These figures as to freight cars and locomotives include new and leased equipment.

Improved Locomotive Frame Bed

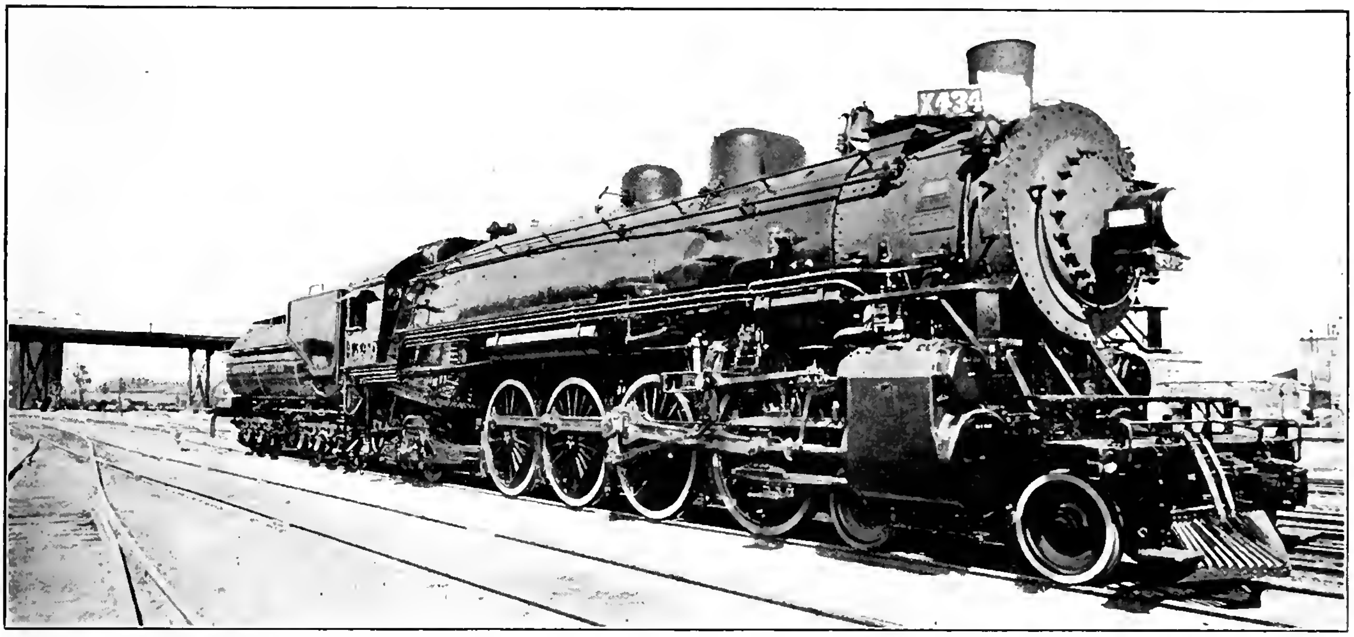
Remarkable Steel Castings

Since the introduction of steel castings in locomotive and car design some thirty years ago, there has been a remarkable growth and development in the use of such casting which has been of great value and advantage to railways.

Some of the great advantages resulting from the extended use of steel castings in locomotive and car design have been; a stronger and superior metal, insuring greater reliability and longer life, marked reduction in weight, and a most remarkable reduction in the number of individual parts, all contributing to a much higher standard of capacity, efficiency and economy. Years ago, the number of parts in the then commonly used four-wheel leading engine truck was reduced from about 48 to 8, by pouring from the molder's ladle, molten metal, thus producing in one casting a far superior unit than the one fabricated by machinists from a combination of grey iron castings, bolts, bars, frames, rods, etc.

In the August 1923 issue of Railway and Locomotive Engineering there appeared a description of one-piece cast steel underframes for box cars. These units displaced approximately 800 individual pieces or parts used in building up or fabricating a similar structure.

Years ago had anyone predicted that large locomotive frames, including deck plate, cradle and the numerous brackets, would be poured in one casting he would have received scant consideration, yet that is exactly what is being done and is now an advanced practice.


Mountain Type Locomotive of the Southern Pacific Railway Having One-Piece Cast Steel Locomotive Bed

Southern Pacific Leaders in Developments

The accompanying illustration shows a 4-8-2 mountain type locomotive recently built in the Sacramento shops of the Southern Pacific Railway under the direction of George McCormick, chief motive power officer of that company, which has as fine an appearance and stream lines proportion of parts, etc., as any engine we have seen.

Five locomotives, similar to the one illustrated, have been built. These engines have cylinders 28 x 30 inches, the diameter of the driving wheels is 73½ inches and the weight on the driving wheels is 246,000 pounds. A working pressure of 210 pounds is used and the engine develops a tractive force of 57,510 pounds, and with booster 67,660 pounds. The total weight of the engine and tender in working order is 610,300 pounds.

There are parts of the engine that are of unusual interest and merit, that testify to the great advancement that has been made in the use of cast steel in modern locomotive design.

Through the courtesy of Mr. McCormick, we are able to present in addition to the photograph of the completed engine, photographs of the cast steel frame bed, including the deck or cradle casting, all in one piece. This one-piece device measures 52 feet 2½ inches long, has a maximum depth of 4 feet 3½ inches, and its maximum width is 10 feet. The weight of the bed complete with pedestal binders is 40,600 pounds. This casting combines in one piece the usual main frames of the locomotive, the firebox cradle casting, front deck, cross ties, brake and equalizer fulcrums, and all of the various fillers and brackets usually cast separately and bolted together in the locomotive frame assembly.

The cast steel used in this engine bed contains about 18 per cent carbon and 73 per cent manganese.

The time required to pour the steel into mold for one complete engine bed was about 11 minutes. The steel was poured through a special nozzle from a ladle containing about 50 tons of molten steel.

There are a number of problems involved in the construction of these beds. After the design was checked by the railway mechanical engineers and approved, patterns were prepared by the Commonwealth Steel Company, then the mold was prepared in a specially constructed metal form lined with silica sand. This special method of molding insures a uniform and accurate casting, true to dimensions.

The question of shrinkage in such a large complicated casting is very important, and requires the most painstaking analysis of the problems in order that the finished bed may come to the proper dimensions.

After the casting was removed from the mold it went through various processes of finishing.

The machining of the various parts of this enormous casting in the Commonwealth plant required such machines as large 10 ft. planers with beds in excess of 30 ft.; specially designed slotters; cross cut planers built specially for certain difficult planing, the heads of the planer moving instead of the bed as with the usual type of planer; radial drills; horizontal drills, etc., in addition to the hydraulic washing of the casting when it was first removed from the mold. Also grinders, pneumatic hammers for chipping, and other tools and machinery were utilized in finishing the casting.

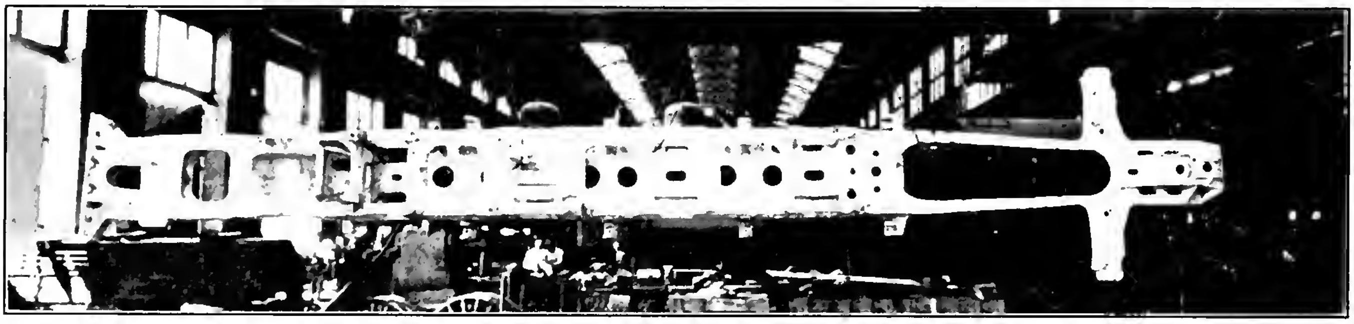
Each one of these beds combined in one casting the usual main frames, consisting of two units; one at each side of locomotive, cross bracing, and the various other parts of the entire underframe of the locomotive. Combining these pieces all in one casting eliminated objectionable splices and bolts together with considerable fitting and finishing which was necessary with the ordinary locomotive frames heretofore used.

Locomotive Bed with Integral Cylinders Cast

One-piece locomotive beds with cylinders cast integral are the striking feature of a group of new switching locomotives built by the Terminal Railroad Association of St. Louis. One-piece locomotive beds are in service on a number of locomotives in operation on different railroads in the country, but this new group of Terminal locomotives, the first to be equipped with locomotive beds, with cylinders cast with the bed, is a great development in locomotive art. The solid one-piece underframe with cylinders attached has peculiar advantages as compared with the ordinary built-up locomotive bed, as there are no parts to get loose, and the casting of the cylinders as a part of the bed does away with a common maintenance difficulty in locomotives, namely, that the cylinders are apt to become loose from time to time.

The locomotive bed should effect a material saving in repairs. It has been estimated that the saving on the ordinary locomotive by the use of the cast steel bed will be not less than $400 a year. This particular bed also reduces the dead weight of the locomotive by about 6,000 lbs. over what it would have been if a built-up underframe had been used.

Side View of One-Piece Cast Steel Locomotive Bed for Southern Pacific Mountain Type Locomotive



Top View of One-Piece Cast Steel Locomotive Bed for Southern Pacific Mountain Type Locomotive

Besides the locomotive bed described above, the Commonwealth Company has also contributed to this group of Terminal locomotives the solid bottom cast steel tenderframe. This new type of tenderframe with the solid bottom lowers the center of gravity of the water in the tender by 12 inches and increases the capacity of the tender, the length remaining the same. In these water-bottom tenderframes, with the bottom cast integral with the tenderframe, all joints at the bottom of the frame are eliminated, thus doing away with the part of the water tank that causes the greatest repairs and is most expensive to maintain. Another new and novel feature of these tenderframes is the welding of the plates forming the tank. Instead of the usual construction of lapped joints riveted together, the Terminal Railroad welded their plates together, also welding the internal braces of the plates, and the whole tank in turn was welded to the Commonwealth cast steel tenderframe, thus forming a tank without rivets and giving a construction which will stand up for a greater length of time and require far less repairs than the riveted tank.

Milling Machine for Finishing Locomotive Beds

The recent development in locomotive bed castings, with the cylinders and cradle cast integral, has presented many problems in machining and made necessary very large and powerful machinery to economically finish these castings.

The new milling machine required 12 cars to transport it from the manufacturers' plant to the Commonwealth Steel Company. An idea of the size of the machine may be gained by the fact that it weighs approximately 500,000 lbs.; the bed upon which the working table rests is about 75 ft. long; it has a clearance of 10 feet between the housings and 8 feet under the ends of the vertical spindles—a space more than ample to drive an automobile through.

Other interesting facts about the machine are: that it requires two 75 horsepower motors to drive the six spindles, one 25 horsepower motor to feed the machine and move the heads and table; and in addition a 2 horsepower motor for lubrication and a 2 horsepower motor for the cutting fluid pump to cool the cutters which has a capacity of 100 gallons per minute.

The installation of this large milling machine, which will perform all the operations heretofore done on large cross planers, slotters, and longitudinal planers, make it possible to machine all the surfaces of a locomotive bed in two settings, thereby insuring absolute accuracy of all the finished surfaces in relation to each other.

The Commonwealth Steel Company of Granite City, Illinois, at whose plant these bed frames were cast and then machined ready for application prior to shipment from their works, have pioneered or specialized in this particular branch of metallurgy, as applied to railway engineering progress, and are deserving of much credit for their achievements in this direction.

New Pacific Type Locomotives of the Baltimore & Ohio

Named After the Presidents of the United States, They Are Used in Fast Passenger Service Between Washington and New York

The Baltimore & Ohio has recently placed in fast passenger service, on the Washington-New York line, 20 Pacific type locomotives built by The Baldwin Locomotive Works; an event of special interest in this, the Centenary year of the Railroad Company. These locomotives are among the most powerful of their type in service, as their tractive force—considering the main cylinders only—exceeds that of any Pacific type locomotives thus far constructed. The service in which they are used has been operated for the past 40 years, and has always been noted for its excellence.

New Pacific Type Locomotive of the Baltimore & Ohio R. R. Built by the Baldwin Locomotive Works

At the World's Columbian Exposition, held in Chicago in 1893, the exhibit of The Baldwin Locomotive Works included a locomotive of the American (4-4-0) type, built for the Baltimore & Ohio, which represented the class of power then used in high speed service on the Philadelphia Division. A comparison of the principal dimensions of this locomotive and of the various types of power subsequently used in this service down to the present time, is given in the accompanying table.

On the Washington-New York run it was formerly the custom to cut off the Baltimore & Ohio locomotives at Philadelphia, 132.7 miles from Washington. Now, however, the locomotives are run through to Jersey City, the trains using the tracks of the Reading Company and of the Central Railroad of New Jersey east of Philadelphia. This means a run of 226 miles each way, and this is made by the fastest trains, in 5 hours, representing an average speed of 45 miles per hour, with nine intermediate stops, to handle maximum trains of 10 or 12 cars on schedules like this, with reserve power for making up a reasonable amount of time, requires motive power of high hauling, steaming and speed capacity; and these qualities are admirably combined in the new locomotives.

These Pacific type locomotives are designated as Class P-7, and develop a maximum tractive force of 50,000 pounds with 201,000 pounds on the driver. One of the locomotives has been fitted with a booster on the rear truck, and the others are so designed that boosters can subsequently be applied if desired. The tractive force is exceptionally high for a locomotive with 80-inch driving wheels, and it is developed by using 27 x 28-inch cylinders in combination with a steam pressure of 230 pounds.

The boiler is designed along conventional lines, with a 38-inch combustion chamber and tubes 19 feet in length. The arch is supported on two water tubes and two syphons, and the combined heating surface of the firebox and combustion chamber is 394 square feet. Water spaces of liberal width are used, the mud ring being six inches wide at the front and five inches at the sides and back. The super-heater has 40 elements, and is of type "A", but without a shut-off damper in the smokebox.

These locomotives are fired by du Pont Simplex stokers, the stoker engine being placed on the tender. The grates rock in four sections, and are without drop plates.

The machinery has been designed for a running speed of 80 miles per hour. The crossheads are of Vanadium cast steel, working in guides of the modified Laird, or hooded type. All the rods are of I-section, and the main rod back-ends, and the side rod connections on the main pins have floating bushings. The driving axles and main crank pins are hollow bored. Walschaerts valve gear is applied, and is controlled by a power reverse. The motion parts are of light design, and the eccentric rods have an I-section. The valves are set with a maximum travel of 7 inches, and they have a steam lap of 1⅛ inches and an exhaust clearance of ¼ inch.

Date	Type	Cylinders	Drivers, diam.	Steam Pressure	Grate Area Sq. Ft.	Water Heating Surface Sq. Ft.	Superheating Surface, Sq. Ft.	Weight on Drivers, Pounds	Weight total Engine Pounds	Tractive Force Pounds
1893	 4-4-0	20″ x 24″	78″	165	24.7	1693	...	75,200	116,400	17,300
1896	 4-6-0	21″ x 26″	78″	190	34.3	2160	...	112,800	146,400	23,750
1910	 4-4-2	22″ x 26″	80″	205	55.5	2350	...	116,000	190,000	27,400
1913	 4-6-2	24″ x 28″	76″	190	56.5	2567	587	159,200	248,600	34,200
1919	 4-6-2	25″ x 28″	73″	200	66.7	3341	794	167,100	275,770	40,800
1927	 4-6-2	27″ x 28″	80″	230	70.3	3846	932			50,000

Baltimore & Ohio Class P-7 Pacific Type Locomotive

Cylinders	27 x 28 ins.	
Valve	Piston, 14 ins. diam.	
Boiler		
Type	Conical	
Diameter	78 ins.	
Working pressure	230 lbs.	
Fuel	Soft Coal	
Firebox		
Material	Steel	
Staying	Radial	
Length	120⅛ ins.	
Width	84¼ ins.	
Depth front	85 ins.	
Depth back	68½ ins.	
Tubes		
Diameter	5½ ins.	2¼ ins.
Number	40	212
Length	19 ft. 0 in.	19 ft. 0 in.
Heating Surface		
Firebox	235 sq. ft.	
Combustion Chamber	64 sq. ft.	
Tubes	3,452 sq. ft.	
Firebrick tubes	14 sq. ft.	
Thermic syphons	81 sq. ft.	
Total	3,846 sq. ft.	
Superheater	932 sq. ft.	
Grate area	70.3 sq. ft.	
Driving Wheels		
Diameter outside	80 ins.	
Diameter center	72 ins.	
Journals, main	12½ x 13 ins.	
Journals, others	11 x 13 ins.	
Engine Truck Wheels		
Diameter front	36 ins.	
Journals	7 x 12 ins.	
Diameter back	52 ins.	
Journals	9 x 16 ins.	
Wheel base		
Driving	14 ft. 0 ins.	
Rigid	14 ft. 0 ins.	
Total Engine	37 ft. 1 in.	
Total engine and tender	77 ft. 6 ins.	
Weight in working order		
On driving wheels	201,000 lbs.	
On truck front	63,000 lbs.	
On truck back	62,000 lbs.	
Total engine	326,000 lbs.	
Total engine and tender	540,000 lbs.	
Tender		
Wheels number	Eight	
Wheels diameter	36 ins.	
Journals	6 x 12 ins.	
Tank capacity	11,000 U. S. gal.	
Fuel	17½ tons	
Tractive force	50,000 lbs.	
Service	Passenger	

The frames are six inches wide, and have most substantial transverse bracing; and the Commonwealth rear frame cradle is applied. The pedestal shoes and wedges are of brass. The rear truck is of the Delta type, and the swing of the trucks, front and back, is sufficient to enable the locomotives to traverse curves of 18 degrees. All the driving tires are flanged, the transverse tire spacing on the main wheels being 53⅜ inches, and on the front and back drivers 53¼ inches.

These locomotives are equipped with force feed lubricators, driven from the valve motion and having six feeds—one to each steam chest, one to each cylinder barrel, one to the stoker engine and one to the air pump. A drifting valve is provided, and is piped into the saturated side of the superheater header. The operating handle of the drifting valve is placed in the cab, while the steam supply is taken through a shut-off valve which is tapped into the dome. The equipment further includes flange lubricators on the leading drivers, speed recorders, and the General Railway Signal Company's automatic train control.

The tender has a one piece, cast steel frame, and a rectangular tank. It is equipped with a water scoop, which is operated by a 12-inch air cylinder.

These locomotives, apart from their size and neat outline, present a striking appearance, as they are painted Pullman green, with gold and maroon striping and gold lettering and marking. They are named after Presidents of the United States. No. 5300 is the "President Washington;" No. 5301, the "President Adams;" No. 5302, the "President Jefferson," and down to President Arthur. The color scheme harmonizes well with that of the trains which they haul.

Further particulars are given in the table of dimensions.

Roller Bearing Record on the C. M. & St. P.

A passenger coach on the Chicago, Milwaukee & St. Paul, the six-wheel trucks of which are equipped with Hyatt roller bearings, is reported to have made 300,000 miles since the roller bearings were applied. A recent examination of the bearings is said to have shown them to be free from wear or other signs of deterioration. On the basis of the conditions of the bearings at the present time, it is estimated conservatively that they will make 600,000 miles. The coach is in service between Chicago and the Pacific Coast, making a round trip every nine days.

Locomotive Fuel Record

Class I railroads in 1926 consumed 101,007,549 tons of coal as fuel for road locomotives at an average cost of $2.63 a ton or a total of $266,054,143, according to the Interstate Commerce Commission's monthly statement; consumption in the previous year 97,404,200 tons; average $2.71 and total costs $263,758,941. In 1926 the railroad also consumed 2,067,272,099 gallons of fuel oil at an average cost of 2.95 cents a gallon, as compared with 2,067,948,551 gallons at an average cost of 3.14 cents in 1925. The cost of coal ranged from $1.83 in the Pocahontas region to $4.58 in the New England region.

Recent Motive Power Developments in Europe

Abstracted from an Address Before the Western Society of Engineers

By C. B. Page, Manager, The Steamotor Company, Chicago, Illinois

The outstanding Diesel locomotive built in Europe in 1926 was the second Russian locomotive designed by Prof. George Lomonossoff and Dipl. Ing. Dobrowolski. The essential difference from its predecessor lies in the driving mechanism, the first locomotive being fitted with electric transmission and the second with a three-speed constant mesh gear transmission and magnetic clutches. Backward motion is obtained by reversing the engine. The thermal efficiency of the engine and the overall efficiency of the locomotive as determined by extensive laboratory tests, were 34 per cent, and 29.4 per cent respectively. This last compares with 25 per cent for the first locomotive with electric drive.

The German State Railways are now projecting a 1,600-hp. Diesel locomotive with gear drive or six speeds forward and reverse and air clutches. The engines are to be four in number, four-cylinders each, four-cycle, and supercharging, which is estimated to improve the overall efficiency by 15 per cent. In the meantime, the Esslinger Machine Works, near Stuttgart, Germany, is completing a compressed air drive Diesel locomotive of 900 i. hp. and is projecting a 2,500-hp. Diesel with a combination direct and compressed air drive.

In his paper a year ago the late W. H. Finley stated that the consensus of European opinion was against electric drive for either gas or oil power. As regards the larger size Diesel locomotive, Prof. Lomonossoff is probably the foremost European authority. It is notable that in his second locomotive he preferred mechanical drive to the electric and in a recent magazine article he favors the former for regular train operation while conceding that the latter possesses advantages for switching service. Certainly the trend to mechanical transmission is now even more pronounced than a year ago. In fact, every authority recently interviewed pronounced in favor of the mechanical type, recommending it even for switching, at least to the extent of stating that before gas and oil power could be regarded as attractive for this service, it would be necessary to perfect some type of mechanical drive.

The question is often raised as to why Europe is so favorable to mechanical transmissions while in the United States the whole commercial trend has been to a larger use of the electric. I have searched long and diligently for the answer. It seems to me that, primarily, Europe uses gas and oil power solely from an economy and efficiency standpoint. They are primarily interested in such matters as first cost, weight, maintenance, depreciation and operating expense. These items must be scaled down to rock bottom if gas and oil power are to compete successfully with steam. In relation to coal, oil is more expensive than here, interest rates are higher; reduction in weight is considered by them of greater importance, and wages are less. Relatively they have no smoke problem, or at least are not particularly concerned with it, hence the Diesel locomotive is pitted in direct commercial competition with steam power. In view, then, of the different conditions existing there and here, the inference should not be drawn that because Europe insists upon the mechanical transmission, the electric drive is not the more suitable to American requirements.

And yet on the other hand, and of great significance, is the recent order placed by a large New England railroad with Krupp for a 1,400-hp. combined freight and passenger Diesel locomotive to be fitted with the same type of transmission built into the second Russian locomotive, namely, constant mesh gears with magnetic clutches, the only difference of moment being that the number of speeds is increased from 3 to 4.

Broadly, what is the European trend in the application of gas and oil power to locomotives? As to road locomotives of 1,000 hp. and over, the moderate interest of a year ago continues without change. Construction of small switching locomotives has practically ceased, due, I believe, to the inefficiency, cost and weight of transmissions, both electric and mechanical, so far used.

During 1926, progress in steam engineering as applied to motive power was particularly marked. Almost every locomotive works of prominence was either bringing to a conclusion and testing some ambitious new design, in many cases quite revolutionary, or had its engineering department working on similar undertakings. Activity was, however, not confined to the entirely new and novel, but embraced, as well, refinements and improvements to conventional construction. It is no reflection on the Diesel locomotive and its prospects to credit to steam a veritable renaissance. The art is, of course, over a century old, is more extensively practiced and perhaps immediately more fruitful. Moreover, it is prompted by the feeling that locomotive engineering, as regards thermal efficiency has so far lagged behind stationary and marine practice as to become almost a spectacle. Something had to be done!

Much progress was made in standardizing construction and types, especially in Germany where, under the auspices of the railway administration, the various locomotive builders some time since established a standardization office with a permanent organization, with the result that 210 former locomotive types have been condensed to 16, which number will be still further reduced as experience justifies. One of the 16 is the new standard German express locomotives, a 4-6-2 type, according to American designation, rated at 2,200 to 2,400-hp. maximum, speed 70 miles per hr. at 292 r.p.m.

Main steam poppet valves of both the Lentz and Caprotti types seem to have passed the experimental stage and are being widely adopted. The former are particularly popular in Austria and Germany and to a lesser extent in Italy. The latter, originated in Italy, are now used extensively by the Italian State Railways and are being tried out in England.

Mr. Fineley's paper of a year ago commented on the marked trend to higher steam pressures for locomotive. This trend was confirmed in 1926. Every locomotive manufacturer, railroad executive, engineer and general engineering counselor interviewed by this writer, affirmed that higher steam pressures for motive power are so close at hand as to constitute almost a fact accomplished. By higher steam pressures the Europeans do not mean 250 to 400 lb. but 850 lb. and over. In this respect locomotive engineering is only following the practice already established by the stationary engineer in which our own American engineers are taking such a conspicuous part.

The 850-lb. working pressure locomotive built by Henschel & Son, Cassel, Germany, under the patents and to the designs and specifications of the Schmidt-Heissdampf-Gesellschaft is well known and has been so fully described in the American technical press that no added details are necessary. This locomotive was exhaustively tested both in the laboratory and in regular service by the builders and was lately turned over to the German railways for official acceptance. R. P. Wagner, chief counselor, locomotive department, German State Railways, reports this locomotive under test. S. Hoffman, managing director of the Schmidt Company, states that their trials showed a gain in economy of at least 25 per cent as compared with superheater locomotives at ordinary pressures.

Again under the patronage of the German railways, the Berliner Machine Works of Berlin are developing a 2,500-hp. piston locomotive featuring the Loeffer system. In this system the combustion chamber is surrounded by tubes in which saturated steam at 1,420 lb. pressure is circulated at high velocity by means of a steam pump, the resulting highly superheated steam being used in part directly in high pressure cylinder and the balance returned to the drum from which it was drawn for the purpose of generating additional steam. Exhaust from the high pressure cylinder is discharged to a large receiver against a maximum pressure of 257 lb. From this receiver the steam is re-superheated on its way to the low pressure cylinder. Mr. Wagner, already quoted, is authority for the statement that a fuel saving of 45 per cent is expected from this locomotive when built.

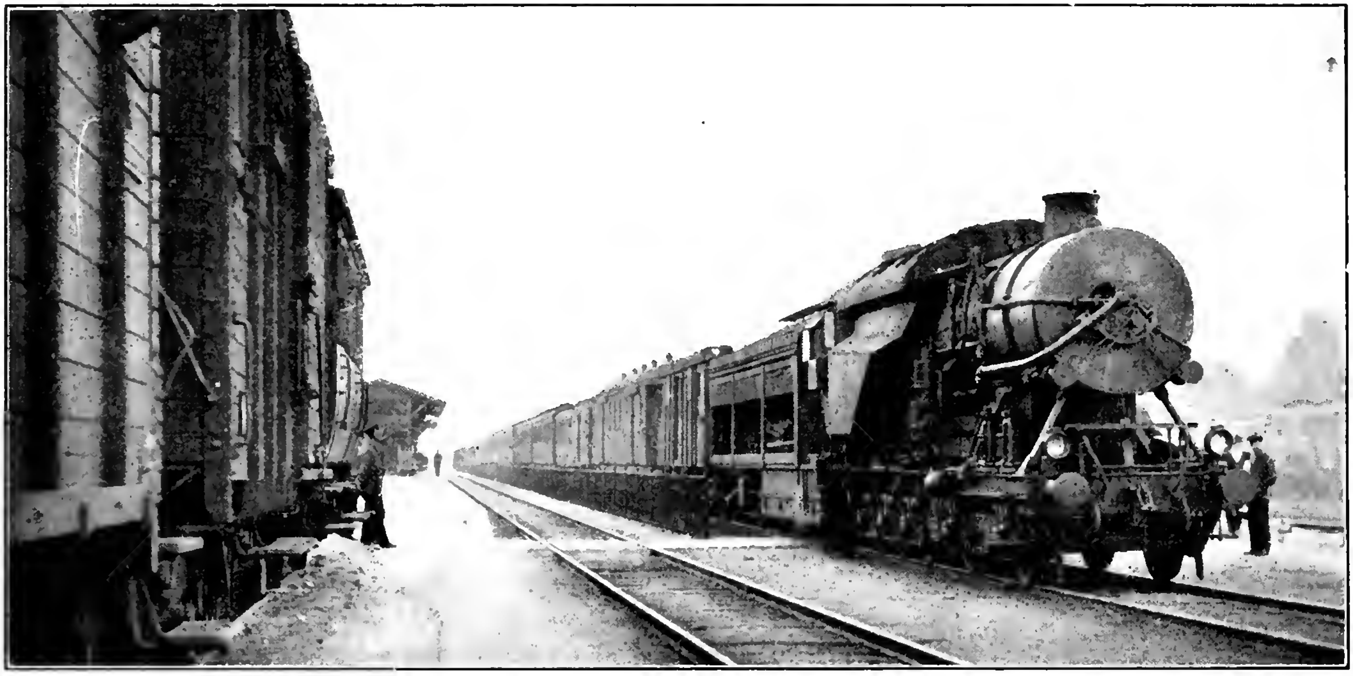
A third high pressure locomotive system is being developed by the Swiss Locomotive & Machine Works of Winterthur, Switzerland. No details of this system are yet available although it is understood that a test plant is now in operation. The working pressure on the high side is given to 60 atmospheres, or 850 lb.

There is a considerable historical background to the present intensive European activity in turbine-driven condensing locomotives. Interest centers in two types, Ljungstron and Zoelly, the first models of which were produced about four years ago.

These two locomotives made such an impression that several of the great firms of Europe, viz., Nydquist & Holm, Trollhattan, Sweden; Beyer-Peacock & Co., Ltd., Manchester, England; Fried. Krupp, Essen, Germany; and Henschel & Son, Cassel, Germany, took out licenses and proceeded with the design and construction of locomotives of various sizes. J. A. Maffei, of Munich, joined this group but along lines independent of either Ljungstrom or Zoelly. Last year saw the completion of all these locomotives, so that they are now either in regular service or under test.

The 2,000-hp. Krupp-Zoelly type locomotive in the fall of 1926 had been brought to a full commercial standard and was ready for its acceptance test by the German Railways, for which system the locomotive had been built.

Henschel & Son's development has been along somewhat different lines, namely, the utilization of the exhaust steam from a piston locomotive in a turbine drive. A 1,000-hp. German railway locomotive is used for this purpose. The tender, however, is entirely new, providing as it does turbine drive, condensers and coal bunker. This general scheme is included within the scope of the Zoelly system and Escher-Wyss turbines are used. Last November, construction was nearly completed and the completed unit should now be on test.



Ljungstrom Steam Turbine Locomotive in Service on the Swedish State Railways

In the fall of last year, J. A. Maffei of Munich, completed, to order of the German Railway, a 2,500-hp. turbo-condensing locomotive which in general appearance has many points of similiarity to the Zoelly system construction, but which differs considerably in detail. The main turbine is a combination action reaction type built in the Maffei works. The reduction gear embodies new ideas, as does also the recooler. This locomotive was subjected to extensive builder's trials and is now in express train service between Munich and Augsburg, distant about 70 miles northwest of Munich.

Early in 1926, Nydquest & Holm, licensee under Ljungstrom, had completed and delivered a 1,750-hp. turbo locomotive to the order of the Argentine State Railways, for service across the Argentine desert. All of the contract requirements for this locomotive have been met and after a year of service, as required by its terms, has been approved. Its final acceptance by the Argentine State Railways depends now only on a final inspection.

The same company has just recently completed its second locomotive, this time of 2,000 hp. to the order of the Swedish State Railways. During February a test run with a train weight of 506 tons was made between Stockholm and Upsala. The average speed maintained was 47 miles an hour; maximum power developed at drawbar, 1,400 hp., everything working perfectly. This locomotive was then scheduled for regular service between Stockholm, Sweden, and Bollnas, a distance of 196 miles, a daily round trip of 392 miles on a time card, including stops, of 12 hours 22 minutes.

Last fall Beyer-Peacock & Company, Ltd., completed a 2,000-hp. Ljungstrom type locomotive. After its test by the builders this locomotive was turned over to the London, Midland & Scottish Railway for passenger train service between Rugby and Manchester, where, according to reports, it was satisfactory in every way. It is shortly scheduled for express train run between Manchester and London and later for non-stop service between London and Glasgow.

While conforming in main essentials to the ideas originally worked out by Ljungstrom, this locomotive embodies many improvements and refinements over the first construction. Moreover, it has been much simplified, especially in its controls. It was my privilege to ride in the cab of this locomotive last November on a test trip of 46 miles. At a maximum speed of 56 miles an hour, my seat was almost as steady as a chair in a Pullman. The acceleration is smoother than an electric because torque is continuous without interruption from zero to maximum speed. The only noise that could be heard was the click of the wheels on the rail joints and the whistling of the wind. I tried to catch the whine of the drive gearing but it was scarcely discernible. In spite of poor firing and a rather poor grade of American coal, the run from end to end was nearly smokeless. A little gray smoke was emitted at each firing but this almost immediately thinned out to a light blue vapor.

The explanation of this smokeless condition is that the builders, with the primary object of getting more economical fuel consumption, have improved the proportions of the firebox and introduced two whirling blasts of highly pre-heated air over the fire. There is needed only the fitting of a mechanical stoker or provision for burning pulverized coal to so reduce the smoke as to satisfy the most particular.

Tests and service performance of the turbo-condensing locomotives to date, substantiate the substance of the claims of the inventors and builders, of which the following are a few:

Continuous driving torque resulting directly in improved adhesion.

Improved roadability.

A gain in economy, ranging from 30 to 50 per cent, depending upon design, capacity and equipment, with a corresponding increase in overall efficiency up to 16 per cent.

Elimination of boiler washing and scaling.

Longer runs.

Less wear on the track.

Greater comfort for the passengers.

Improved conditions for engineman and fireman.

Decreased cost of maintenance.

Higher train speeds.

First cost is given as 1.8 times to twice that of the modern super-heater piston locomotive. Savings, however are calculated to wipe out this additional cost in from 3½ to 4 years.

I have set forth above what appears to be just the beginnings of the commercial development of the turbo-condensing locomotive. Krupp has completed designs for an 850-lb. working pressure turbo-locomotive of 2,000-hp. The boiler is of the watertube type, following rather closely some previous marine practice. Henschel & Son has plans complete for a 2,000-hp. rigid frame locomotive. Maffei is projecting a 2,500-hp. locomotive utilizing even higher working pressures than heretofore discussed. Beyer-Peacock & Company, Ltd., is looking forward to a very ambitious production schedule. One group in France headed by the great Schneider Works is in readiness to proceed with the construction of Zoelly type turbo-locomotives, while another group is being formed for building under the Ljungstrom patents.

Today, the majority of the best informed European opinion, while anticipating no immediate and wholesale replacement of the present day steam locomotive, does believe, nevertheless that motive power thermal efficiency must and will be brought to a closer parity with stationary and marine performance. The Diesel locomotive with some form of mechanical drive is conceded a place in the new picture. However, main dependence, as now, will be placed on steam power very much improved in thermal efficiency, possibly quite different in form from our present day conventional type but still a steam locomotive.

Metal Ties Made from Scrap Rails

Metal railroad ties, constructed by electric arc welding from worn rails, are not only ten times as strong as the ordinary wooden type of tie, but can be made at a very low cost, according to William Dalton of the General Electric Company. Mr. Dalton recently completed a test extending over a period of a year in collaboration with H. S. Clarke, Engineer, Maintenance of Way, Delaware and Hudson Railroad.

A number of sample ties were installed by the D. & H. about a year ago in its Glenville Yards. The test has been so successful that Vice President Loree has decided to undertake the substitution of metal for wooden ties in Yards & Sidings, and arrangements are now being made by that Railroad Company to install equipment in its shops for the construction of the ties.

The tie design as worked out by Mr. Dalton, involves the use of two pieces of rail for each tie. The rail used is that which has been removed from the roadbed as worn and has no value except as scrap. The two lengths are fastened together at each end by metal plates welded in position. The L-shaped angle bars used in ordinary rail joints can be used for this purpose. When two rails are fastened together in this manner, movement of the tie in any direction in the ballast is eliminated.

For fastening the track to the tie, metal plates are welded to the tie and the track clamped to these with special clamping devices which cannot slip out of place. As any holes punched in the tie bars for rail clamps would destroy the efficient use of the bar material, the use of separate plates fastened to the tie bar eliminates trouble in this connection. As the edges of the tie plate are placed over the center of the top flange of the tie bars, the wave action of the rail throws the load directly over the webs of the tie beams instead of on the outer edge of the flanges. This construction also reduces the number of rail clamps to a minimum.

An analysis of costs of wooden versus metal ties made by the D. & H. shows a total cost of $2.80 for the wooden variety. The total cost of fabricating a metal tie of the type designed by Mr. Dalton is 60 cents, and the scrap value of the tie is $2.50 making an overall cost of $3.10. Inasmuch as the scrap value can be realized out of the rail when it is later discarded from tie service, the net cost of the metal tie is reduced to the cost of fabrication or 60 cents, as against a cost of $2.80 for wooden tie.

Present applications have been confined to yard and siding service. This field, however, requires over 30,000,000 ties a year for replacements. An insulator between the tie and the rail will be required on main lines using automatic signalling.

Railway and Locomotive Engineering

A Practical Journal of Motive Power,
Rolling Stock and Appliances

Published Monthly by
ANGUS SINCLAIR COMPANY
136 Liberty Street, New York
Chicago Office: 168 North Michigan Avenue
Telephone Rector 0746. Cable Address "Locong." N. Y.

Harry A. Kenney, Prest. and Man. Ed.
J. Snowden Bell, Associate Editor
W. E. Symons, Associate Editor
Thomas P. Kenney, Secretary

LONDON REPRESENTATIVE
The Locomotive Publishing Company, Ltd., 3 Amen Corner, Paternoster Row, London, E. C., England.

SUBSCRIPTION PRICE

$2.00 *per year,* $1.00 *for six months, postage paid in the United States, Canada and Mexico. For other parts of the world,* $2.50. *Single copies,* 20 *cents. Remit by Express Money Order, Draft, Post Office Order or Registered Letter.*

Mailing address can be changed as often as necessary—always give old and new address, and if you subscribe in a club, state the name of the agent.

Please give prompt notice when your paper fails to reach you regularly.

Entered as second-class matter January 15, 1902, at the post office at New York, New York, under the Act of March 3, 1879.

The Steam Turbine Locomotive

With the view of obtaining radical thermal and mechanical improvements in the conventional design of steam locomotives and also a higher rate of acceleration corresponding to that obtained with the electric locomotive, a number of attempts has been made to apply the steam turbine to locomotives. Several designs have in recent years made new appearances, notably the Ljungstrom in Sweden, the Zoelly in Switzerland, the Lomonosoff in Russia and the Reid-MacLeod design which is described elsewhere in this issue.

The Reid-MacLeod locomotive is the product of the North British Locomotive Company, Ltd., of Glasgow, Scotland. Some years ago this same concern built a turbine engine which was subsequently tested in the actual service, during which the principles of the construction were largely sustained and they later produced a number of steam turbine applications. This new geared turbine locomotive is a noteworthy development that has attracted wide attention.

Speaking generally of turbine locomotives, the principle has been in some instances to take advantage of the special attributes of the steam turbine, overcoming the difficulties occasioned by the variable conditions under which the ordinary steam locomotive has to work, by applying the turbine to drive a dynamo which supplied current for traction electric-motors.

In the design under consideration geared turbines have been directly applied for traction purposes. Since the turbines actuate the driving wheels, coupling rods are dispensed with and the absence of reciprocating parts does away with the balancing problem of the ordinary steam locomotive. This in itself is an important advantage in that the track and bridge structures are not subjected to the shocks usually associated with the operation of the conventional steam locomotive. This feature may open the way for the use of heavier weights on driving wheels. Another advantage is the fact that a uniform torque is obtained with a consequent rapid acceleration which approximates that secured with the best of electric traction.

The combination of two stage turbines with a condenser secures expansion of the superheatered steam from boiler pressure to condenser vacuum and provides a supply of hot feed water free from impurities for the boiler. Estimated economies as high as 50 per cent in fuel and water have been made for the design.

While this new design is of considerable interest in that it has features that should provide important advantages in thermal efficiency, mechanical improvements and may show much economy in operation when compared with the ordinary steam locomotive, the initial cost of the locomotive like other turbine designs must have been extremely high. While the figure is not available, we recall that another British development of some years ago that embodied the turbo-electric feature was said to have cost $350,000. Experience with that engine enabled designs of a greatly simplified character such as the Reid-MacLeod type, but the initial cost of a turbine driven locomotive of sufficient capacity for American railway traffic would be so high as to make its extended use seem almost prohibitive. The sponsors of the present Reid-MacLeod locomotive maintain that taking fifteen years' operation as a basis, that there should be a net saving of not less than the entire initial capital cost of the reciprocating locomotive, after allowing depreciation and the return of the initial capital difference between the turbine and reciprocating locomotives at five per cent interest.

Roller Bearings on Railway Equipment

In the November, 1926, and February, 1927, issues of Railway and Locomotive Engineering, their appeared articles dealing with the application of anti-friction bearings to railway equipment in this country and elsewhere. In the present number there appears an article dealing with some of the developments abroad, including tests that have been carried on German and French railways.

In connection with the report of the German investigations, it is interesting to note that the Federal Railways have in use seven different makes of anti-friction bearings. These include ball, roller, spherical, cylindrical, pendulum, and the collar roller designs.

The report also indicates that every third car with plain lubricated bearings, which in that country are composed of 85 per cent tin, burns a bearing once a year. Some of the economies that may be effected with the use of anti-friction bearings are evident in that it costs approximately $2.38 to replace a burned bearing alone. This would amount to $595,000 a year alone, for the 250,000 cars effected. Add to this the fact that the cars are out of service for three days, so that on this account 750,000 car days are lost aside from the disturbance of train schedules, and the wonderful possibilities of anti-friction bearings are apparent.

Amongst the interesting features brought out in the French tests, some of which appear to be new, the following seem to invite comment:

1.—The purpose of the tests, as stated by the author of the report were "to measure scientifically the saving in pulling force that it would be possible to reach at various speeds." Yet, the difference in the resistance due to rolling friction in starting trains from a state of rest, one of the real essential questions of the whole matter seems to have been neglected if not ignored. The reason being, it may be assumed, that the locomotive used was so much larger and more powerful than was actually required for the weight of the train, that the question of rolling friction in starting was not considered as one of the factors involved.

2.—That while it is inferred that the suction created at the end of the train when running would be of greater importance than the air pressure at the front end of a train as an obstacle to its motion, the tests have not contributed anything to throw any definite light on this subject.

3.—That while economies in fuel of from 15.78 to 24.77 per cent, or an average of 20.67 per cent is shown in favor of spherical bearings, it is pointed out that even where a reduction of 15 per cent in resistance is shown, that it would only mean a fuel economy of about one-half of that amount, say 7 or 8 per cent, since the engine consumes about one-half in moving itself. But, this estimate is not qualified as to the particular speed of the train.

It is also interesting to note that the chief mechanical engineer of the Swedish State Railways, while endorsing anti-friction or roller bearings as used on passenger cars, is of the opinion, that after the engine crews become more familiar with or more expert in the handling of trains so equipped that the economies of the roller bearing will be considerably augmented. This feature as also the question of suction or negative effect of atmosphere on the rear end of trains running at high speeds are two, that so far as we are aware, have not been considered of importance by American engineers.

A highly interesting study of the economical advantages of the roller bearing and locomotive booster in suburban train operation has been made by the Chicago, Milwaukee & St. Paul Railway. We are indebted to L. K. Sillcox, Gen. Sup't Motive Power of the railway for furnishing us the details of the study which reached us too late for inclusion in the present issue. A full report of the study will appear in our issue for May.

A Summary of Railway Operation in 1926

Railway operations in 1926 have been summarized in the following manner by Dr. Julius H. Parmelee, Director, Bureau of Railway Economics. His analysis is based upon complete statistics of transportation performance during last year, which have just become available.

1. Record breaking freight traffic, which continued throubhout almost the whole of the year at a high level.
2. Passenger traffic that fell 1.5 per cent below 1925. The passenger business in 1926 was less than in any year since 1916.
3. Satisfactory condition of transportation service, there being only a few and local instances of congestion or accumulation, and an almost complete absence of car shortage.
4. Conditions of virtually maximum performance in many of the factors of operation, and a high level of attainment in all other factors.
5. Total operating revenues greater than in any previous year.
6. Total operating expenses greater than in any previous year except 1920 and 1923.
7. Further reduction of the operating ratio, bringing it down to 73.1 per cent for 1926, and lower than in any year since 1917.
8. A total of railway taxes that for the first time surpassed $400,000,000.
9. Net raiilway operating income greater than in 1925 by 8.2 per cent, and greater than in the previous peak year of 1916. The rate of return on property investment for the year was 5.13 per cent, which was less than in 1916. Because of rapid growth in railway capital investment during recent years, the improvement in rate of return has been much slower than in aggregate net income.

"Railway achievement during the past four years can be attributed to the conscious development of a program of cooperative effort," Dr. Parmelee states. "To a greater degree, the same comment applies to the results for 1926. Those results proved even more successful and satisfactory in 1926 than they did in the earlier years. It may again be emphasized that the efficient operation of 1926 was not the outcome of chance, but was the effect of the gradual unfolding of a definite program, by which the railways since the beginning of 1923 have invested more than three and a half billions of new capital in their properties, have secured a fine degree of cooperation from shippers and the general public through the extension of the shippers' advisory board movement, and have developed a fine spirit of loyalty on the part of railway employes.

"Adequate, prompt; and dependable transportation service has speeded up industrial processes everywhere. It has enabled manufacturers to operate with smaller stocks, on more definite schedules, and in the confidence that their materials will come in and go out as and when promised. It has enabled merchants to work on a lower margin of inventories. All this has meant reduction in credit demands, partial release of 'frozen assets,' saving in interest charges, and corresponding benefit to the whole economic structure, from producer through distributor and financing agent to the final consumer.

"The economic contribution of all this to the national welfare cannot be appraised, but it is none the less real and definite even though not calculable.

"As a result the economic place of the railways in our industrial life is today recognized and appreciated as probably never before in our history."

Fire Prevention on the Pennsylvania

Largely through efficient fire prevention methods and the promptness of Pennsylvania Railroad employes in extinguishing fires on railroad property with the company's apparatus before the arrival of municipal fire fighters, the loss to the properties of the company endangered by fire during the year 1926 was kept down to less than one twenty-fifth of one per cent.

Pennsylvania Railroad employes extinguished 235 fires last year on company premises. The losses caused by these fires amounted to only $14,000, or less than $60 per fire, while the work of the employe firemen protected railroad property valued at $38,000,000.

Fire prevention work on the railroad includes thorough instruction of employes in regard to fire hazards and in fire-fighting methods, organization of fire brigades, and use of modern fire extinguishing apparatus. Almost every type of fire apparatus is used in protecting the many railroad buildings along the company's 12,000 miles of track.

The report shows that out of the 235 fires extinguished by employes, organized fire brigades among the workers put out 68 with a loss of only $3,900 in properties insured for nearly $21,000,000. Chemical extinguishers, water casks and fire pails were used in extinguishing 84 fires in which the loss was $3,600. The buildings and rolling equipment involved had a total valuation of $15,590,000.

The company's independent high pressure fire lines were brought into service to extinguish only five fires, which caused a loss of only $1,270 in property worth $818,000. Locomotives equipped with fire fighting apparatus put out 10 fires in properties valued at $447,000 with a loss of only $372.

"Are Our Railroads Costing Too Much?"

W. G. Bierd, Receiver of the Chicago & Alton addressed the last convention of the A. R. E. A. as follows:

Assembled here, we may well say, are the scientific men of the American railways, the railroad engineers. These gentlemen, all of scientific training, are capable of analyzing, thereby learning the needs of the American railroads, and today when we refer to the railroads of this country, we must also consider and give serious thought to other means of inland transportation, because each is so seriously affected by the other that they cannot well be divorced. One is directly competitive with the other. The principal two of these are, first, the railroads; and, second, the motor vehicle and public highway transportation. The third and less important is transportation by the inland waterways.

Let us briefly review the investments in the two first named transportation systems:

RAILWAY AND THEIR EQUIPMENT		IMPROVED HIGHWAYS AND MOTOR VEHICLES	
Miles	251,000	Miles	495,000
Locomotives	70,000	Motor Trucks	2,500,000
Freight cars	2,440,000	Automobiles	17,430,000
Passenger cars	56,500	Motor Buses	70,000
Rail Motor cars	500		
Total Units	2,567,000	Total Units	20,000,000
Investment	$25,000,000,000	Investment	$25,000,000,000
Annual Cost	6,310,000,000	Annual Cost	12,125,000,000
FIVE YEARS AGO IT WOULD HAVE BEEN			
Miles	253,000	Miles	370,000
Locomotives	70,600		
Freight cars	2,400,000	Motor Trucks	1,000,000
Passenger cars	56,150	Automobiles	8,220,000
Rail Motors	50	Motor Buses	5,000
Total Uits	2,526,800	Total Units	9,225,000
Investment	$22,000,000,000	Investment	$13,800,000,000
Annual Cost	6,360,000,000	Annual Cost	6,000,000,000

Twenty-five years ago an inventory for the highways would have been blank so far as present modern highway improvements are concerned. The railways would have shown $10,500,000,000; and the annual cost of railway transportation about $1,500,000,000, or one-twelfth of this country's present-day annual cost of transportation.

Considering these sums so large that they are incomprehensible, great and powerful, almost invincible, as the American people are, these sums mounting up so rapidly as they are indeed alarming even to this great people.

Is the subject of these remarks, therefore, appropriate, and is the American people's transportation costing too much? And in particular are our American railroads' operations costing too much?

I am not subject to alarm. I am not in the slightest degree pessimistic. To the contrary, a great people must expect great results, and great tasks require great men to work out these great problems successfully.

Nevertheless, when we contemplate the enormous growth, the enormous investment and the enormous cost of operation for the last 25 years, must we not hesitate, must we not begin to take stock of our conditions, to know that our methods are sound? Otherwise, are we not subject to great errors that assuredly threaten danger to the well-being and prosperity of the people?

The American people have been, and still are, passing through a most unusual period, a prosperity, that has never before been known or realized by any people. I fear that this unusual prosperity has resulted in a reckless mode of life and most reckless business methods. Every branch branch of industry, including agricultude, and also the American railroads or our transportation systems; every branch of society, those of the great centralized districts, as well as those of the rural areas, have also, hand in hand, set out upon this uncharted sea, practically throwing away both rudder and compass and are drifting with this most extravagant custom of all time.

To my mind it is impossible to continue this for any considerable period of time without inviting and realizing a crisis. Therefore, if these well known facts are worthy of consideration should not the business man of today begin seriously to consider a change in the method of conducting his affairs

Our railroads are 100 years old. However, the railroad systems of today are practically the result of efforts of the past 45 to 50 years. But the more striking feature in which lurks the harm, the danger, is that during the past 12 years, or since the world's great upheaval, these most extravagant demands, these most extravagant things, have occurred. We observe that our cost of transportation 25 years ago, was but one-twelfth our present cost of transportation, and sub-divided again, one branch of this transportation has more than doubled in the past 7 years. In our railroads is invested about twenty-three billions In our public highway transportation is invested about twenty-five billions, with an annual cost of eighteen billions. Can the American people support this mode of life, this runaway extravagance, and avoid danger? I think not.

I believe we can safely say that the American railroad mileage, and its facilities, have been essential and necessary up to the present time, but I fear we cannot say, with the same degree of assurance, that our present-day costs are sound and can be maintained. Beginning with, and since, federal control of the roads, our cost of maintenance, operation and taxes, has increased well above 100 per cent, whereas the rates of revenue to support these costs have increased about 52 to 56 per cent.

The roads have weathered this condition because of an unprecedented volume of traffic, but to my mind we have arrived at the danger point, because the costs of maintaining and operating the railroads, including taxes, are still increasing, whereas there is an equal decrease in the rates of income. Therefore, our curves of income and outgo are sharply diverging, one because of the constantly increasing demands of labor and materials, the other by constant demand for decreased rates of carriage.

There is not an adjustment of rates that does not tend downward, whereas to the contrary, every adjustment as to wages and the costs of many commodities is as certainly upward, although these costs are now at the war-peak levels. We, therefore, have but one hope, which is a further increase in volume of business; but certainly that too has reversed itself and we are now on the decline, and a most sharp decline, in comparison with former years.

It is in these three factors that I see our danger, which in my judgment seriously threatens the business stability of this country. The American people, seemingly, during this period of extravagance have lost control of themselves and they are demanding such transportation methods that it seems impossible they can support that for which they are asking.

Public highway transportation, or the motor vehicle, in my judgment, has come to stay, but it is costing the people such a tremendous sum that they are now realizing that they have contracted for something which they cannot support. The greater part of this transportation must be looked upon as a convenience, in fact a pleasure rather than a necessity. The people are already greatly disturbed, indeed they are groaning under the burdensome load, but it is their own and individual doing, therefore they are loath to admit it or depart from it.

On the other hand, essential to their interest as the railroads are, there is a growing demand for a greatly lessened cost of railroad transportation. No matter how persistently the railroad officer may contend for his share, no matter how he shows what his condition is, public opinion which governs public supervision has set in against the railroads, and local trade centers, chambers of commerce, business organizations, state commissions, federal commissions and the Congress itself, are demanding such changes or modifications in the rate structures which govern our income, that it will be impossible to resist this movement. The railroads will be compelled to yield to a lessening in their cost of transportation. This is certain and it cannot be stopped, because every controlling power, including the federal government, is demanding decreases in the cost of railroad transportation.

We now witness the next extravagance, the wholly unnecessary expenditure, because a few men organize themselves into a working force and set out to cater to local opinion and local sentiment, making extravagant promises and assertions that a new branch of transportation is necessary. And so we have the movement for a Great Lakes to the Gulf waterway, and from the western shore of the Great Lakes to the Atlantic Ocean by the St. Lawrence waterway; and serious as it seems, I fear the people will be led on into supporting these movements, thus again burdening the people with such taxation and such transportation charges that a further revolt will occur. It is positively certain that these three methods cannot be supported; first, because the traffic is not here; and second, the people cannot bear the cost. All of these conditions are the direct result of the extravagant methods of life, and the extravagant method of business of the American people.

The first great alarm, or great demand to change the condition is now coming from the agricultural people. You cannot stop that demand. The President's veto of recent legislation will stop it. The thirty million people who have allowed themselves to be drawn into this extravagant method are rebelling, because they realize they cannot support the present-day conditions.

Let us ask ourselves if there is any other industry in the world so governed, so hampered and so controlled by wholly disinterested persons, without a particle of responsibility as to the welfare of continued existence of such enterprise. The answer is "No." I, therefore, come back to the text of my remarks: "Is the cost of operating our railroads too high?" There can be but one answer and that is "Yes." Therefore, must we not unitedly, determinedly, and definitely join to combat this extravagant control, without responsibility, of the American railroads?

New Six-Coupled Switching Locomotives for the S. A. L.

With a Tractive Force of 45,000 Pounds, They Rank Among Most Powerful of the Type Ever Built

Six-Coupled Switching Locomotive of the Seaboard Air Line Built by the Baldwin Locomotive Works

The Seaboard Air Line has recently received, from The Baldwin Locomotive Works, 25 switching locomotives of the 0-6-0 type. These locomotives were built in accordance with specifications furnished by the Railway Company, and are designated as Class F-7. They weigh without tender 180,000 pounds, and as the maximum tractive force is 45,000 pounds, they rank among the most powerful locomotives of their type thus far built.

Class F-7 is suitable for general switching service, and is designed to traverse curves of 22 degrees. The driving tires are all flanged. Maximum tractive force is developed when cutting off at 65 per cent of the stroke, and to accomplish this the valves have a steam lap of 2½ inches, and are set with a travel of 8¾ inches. The lead and the exhaust lap are each ⅛-inch. The valve gear is of the Baker type, controlled by the Ragonnet power reverse mechanism.

The cylinder barrels are bushed with gun iron, and are lubricated by a mechanical lubricator. Carbon vanadium steel is used for the piston rods, main and side rods, crank pins and driving axles, the last named being hollow bored.

The boiler has a wide firebox, with a grate which is almost square in plan, as the length exceeds the width by only six inches. A brick arch is applied, and is supported on four water tubers. The superheater is a type A, with 26 elements, designed for use with a Chambers smokebox throttle.

The boiler accessories include two steam turrets, one supplying superheated and one saturated steam. The superheated turret draws its supply from the left hand steam pipe in the smokebox, and is tapped for the blower valve, dynamo valve, whistle, and air pump, with provision for future application of a tender booster. The saturated steam turret is tapped for the injector steam valves, power reverse valve, coal sprinkler, and ash-pan flusher valves; and provision is made for future connection to the air pump, should this appear desirable.

The tender has a one-piece cast steel frame, and rectangular tank. The side sheets are curved inward at the top, to afford maximum clear vision for the engine crew. The coal and water capacities are respectively 16 tons and 8,000 gallons.

Further particulars are given in the table of dimensions.

Six-Coupled Locomotive of the Seaboard Air Line Railway, Class F-7

Cylinders	23 x 28 ins.	
Valve	Piston, 12 ins. diam.	
Boiler		
Type	Straight top	
Diameter	70 ins.	
Working pressure	205 lbs.	
Fuel	Soft Coal	
Firebox		
Material	Steel	
Staying	Radial	
Length	78⅛ ins.	
Width	72 ins.	
Depth front	68¾ ins.	
Depth back	66¾ ins.	
Tubes		
Diameter	5½ ins.	2 ins.
Number	26	160
Length	15 ft. 0 in.	15 ft. 0 in.
Heating Surface		
Firebox	144 sq. ft.	
Tubes	1,808 sq. ft.	
Firebrick tubes	20 sq. ft.	
Total	1,972 sq. ft.	
Superheater	452 Sq. ft.	
Grate area	39 sq. ft.	
Driving Wheels		
Diameter outside	51 ins.	
Diameter center	44 ins.	
Journal	10 x 13 ins.	
Wheel base		
Driving	12 ft. 0 ins.	
Rigid	12 ft. 0 ins.	
Total Engine	12 ft. 0 ins.	
Total engine and tender	52 ft. 1 in.	
Weight in working order		
On driving wheels	180,000 lbs.	
Total engine	180,000 lbs.	
Total engine and tender	345,300 lbs.	
Tender		
Wheels number	Eight	
Wheels diameter	33 ins.	
Journals	6 x 11 ins.	
Tank capacity	8,000 U. S. gal.	
Fuel	16 tons	
Tractive force	45,000 lbs.	
Service	Switching	

Mechanical Division A. R. A. Program

The program for the convention of the American Railway Assiciation, Division V—Mechanical, will be held at the Windsor Hotel, Montreal, Quebec, June 7, 8, 9 and 10, with morning and afternoon sessions. The program is as follows:

First Day—June 7

Invocation by Canon Shatford, Church of St. James the Apostle, Church of England.

Welcome—Mayor Martin of the City of Montreal.

Address by Premier King of the Dominion of Canada.

Response by R. H. Aishton, president, A. R. A.

Address, "The Man Problem," by Samuel O. Dunn, editor, *Railway Age*.

Address by L. K. Sillcox, chairman of the Mechanical Division and general superintendent motive power, C. M. & St. P.

Action on minutes of 1926 annual meeting.

Appointment of committees on subjects, resolutions, correspondence, etc.

Unfinished business.

Report of General Committee.

Discussion of reports on nominations; Design of Shops and Terminals; Couplers and Draft gears; Specifications and Tests for Materials; Brakes and Brake Equipment; Lubrication for Cars and Locomotives.

Second Day—June 8

Addresses by Hon. Frank McManamy, Interstate Commerce Commissioner, and M. J. Gormley, chairman, Car Service Division, A. R. A.

Individual paper on Railway Motor Transport with Particular Reference to the Mechanical Problems, by F. J. Swentzel, mechanical superintendent, New England Transportation Company.

Discussion of report on Automotive Rolling Stock.

Individual paper on Passenger and Freight Car. Design, by V. Willoughby, general mechanical engineer, American Car & Foundry Company.

Discussion of reports on Car Construction; Arbitration; Prices for Labor and Materials; Tank Cars; Loading Rules, Safety Appliances (including report from H. A. Johnson, director of research).

Third Day—June 9

Address by A. G. Pack, chief inspector, Bureau of Locomotive Inspection, Interstate Commerce Commission.

Individual paper on Oil Engines for Oil Engine Locomotives, by A. I. Lipetz, consulting engineer, American Locomotive Works.

Discussion of reports on Locomotive and Car Lighting, and Locomotive Design and Construction.

Individual paper on the topic, What Is Left That Has Not Been Done to Attain the Maximum Theoretical Return from the Steam Locomotive: From the standpoint of traction, by W. H. Winterrowd, vice-president, Lima Locomotive Works; from the standpoint of combustion, by L. H. Fry, Baldwin Locomotive Works.

Individual paper entitled "A Look Into the Future," by Prof. A. T. Wood, Pennsylvania State College.

Individual paper on Passenger Cars by G. E. Smart, Chief of car equipment, Canadian National Railways.

Election and installation of officers.

Fourth Day—June 10

Addresses by A. A. Potter, dean of engineering, Purdue University, and Prof. W. J. Cunningham, Harvard University.

Discussion of report on electric rolling stock.

Development of Mechanical Department in Locomotive drive and the Possibilities of thereby Reducing Waste and Increasing Power," by Dr. W. F. M. Goss.

Discussion of report on utilization of locomotives.

New Method for Cleaning Box Cars

American Railway Association has announced a plan by which closed freight cars, which have been contaminated with oil, grease or other liquids, can be cleaned. A special preparation devised by the Association is recommended. Cars cleaned with this preparation will thus be made suitable for all sorts of commodities.

Box cars and refrigerator cars the interiors of which are contaminated by oils, grease or other liquids or in which offensive odors are present, are frequently loaded with flower and cereals, sugar, rice, butter, eggs, dressed poultry, cheese and other food products, resulting in large damage claims being paid by the carriers. It is also often necessary to haul cars empty long distance to supply the demand for such loading when there may be found many cars in the vicinity that are suitable axcept that their interiors have become contaminated from previous loadings. It has been demonstrated by tests that, with the aid of certain cleansing properties, the majority of such cars can be made safe for the carriage of the commodities above mentioned.

Feedwater Heaters on Locomotives[*]

By V. L. JONES, Assistant Mechanical Engineer, New York, New Haven & Hartford, New Haven, Conn.

Application of a locomotive appliance carries with it the necessity for a proper balance sheet that will show all costs involved, fixed charges and economies not only directly on the locomotive itself, but also charges or economies arising at terminals, shops and train operation, so that a proper balance may be drawn that will show a net profit of reasonable size after all figures have been considered.

It is advisable, if possible, to select a typical locomotive on which the boiler and engine relations are known. If no such tests are available, fairly reliable data can be calculated from normal operating figures, locomotives dimensions and test data available throughout the country. Guarantees will be required from the manufacturer of the equipment as to temperatures of feedwater that can be expected with certain exhaust steam pressures and the amount of live steam required for the pump. With this information at hand, the analysis can proceed.

It appears that locomotive performance will be subjected to some change in the following items:

1.—Fuel burned per pound of steam produced.
2.—Amount of superheat.
3.—Overall boiler efficiency.
4.—Back pressure in cylinders.
5.—Overall thermal efficiency.
6.—Tender capacity.

It is thought that time may be saved by following through an example rather than treating and analyzing each factor separately. The following data, which are average, are used as basic information:

Temperature of the water in the tender......	60 deg. F.
Temperature of the water entering the boiler check	230 deg. F.
Rate of firing (per sq. ft. grate area per hr.) for 100 per cent boiler pressure........	90 lb.
Boiler efficiency at above firing rate, per cent.	65
Steam required by pump (per cent total evaporation)	2
Boiler pressure	200 lb. gage
Back pressure in cylinders (within heater)..	10 lb. gage
Size of tender tank.....................	10,000 gal.

Let us first consider the possible fuel saving. If the water enters the heater at 60 deg. F. and is 220 deg. at the boiler check, approximately 160 heat units have been added to each pound by the exhaust steam. The total amount of heat to change a pound of water at 60 deg. F. into saturated steam at 200 lb. pressure is 1,171 heat units.

However, more steam will now be required as a steam driven pump has been added. The pump will take about two per cent of the boiler capacity. Therefore, 102 lb. of steam will be required from the boiler for each 100 lb. going to the cylinders and all other auxiliaries. The percentage reduction in heat from the fuel caused by adding 160 heat units from exhaust steam and increasing the demand by two per cent is

$$100 - \frac{102\,(1{,}171-160)}{1{,}171} = 12 \text{ per cent}$$

This is direct effect of the heat alone, but it is not the whole story. The efficiency of a locomotive boiler always increases as the amount of coal fired is decreased. This condition is well understood and while the percentage rate may differ on different boilers, it always increases. Because of this fact a reduction in the amount of coal burned caused by adding heat to the water from exhaust steam will result in an increase in boiler efficiency. This means that a greater proportion of the heat will now go into the boiler and for any selected quantity of steam there will be a further reduction in fuel.

For the locomotive under consideration, a firing rate of 90 lbs. of coal per sq. ft. of grate per hr. has been assumed and at this rate, the boiler efficiency is taken as 65 per cent. Twelve per cent reduction in fuel gives 79 lb. per square foot per hr. as the new rate, and at this rate the boiler efficiency will be increased about three per cent. The reduction in fuel, due to this is

$$79 \text{ lb.} - \frac{79 \times 65}{68} = 3.5 \text{ lb.}$$

This is an additional 3.9 per cent reduction in fuel and is independent of the 12 per cent saving made from waste heat in exhaust steam.

Adding the 12 per cent and 3.9 per cent savings gives a gross saving of 15.9 per cent.

The next factor to be considered is the effect on the superheat. As just determined, there is now about 16 per cent less fuel required for evaporation, while the output in pounds of steam per hour has not been decreased. This means that the same quantity of steam is passing through the superheater units but a decreased amount of hot gases is passing around them and therefore we can expect less heat available for the superheater and consequently a lower superheat. However, the lower rate of combustion increases the efficiency of both the boiler and superheater, and the reduction to be expected is not in the same ratio as the quantities of steam and gas. An increase from 65 per cent to 68 per cent in boiler efficiency is a gain of 4.6 per cent. Although there are now 83.6 lb. of gases where before there were 100 lb., because of the increased efficiency, 87.3 per cent as much heat will go into the superheater as formerly. Reference to the steam tables shows that this will reduce the superheat from 250 deg. F. to about 218 deg., a reduction of about 32 deg.

At 45 per cent cutoff, steam consumption per indicated horsepower hour will increase about six per cent when the superheat is reduced from 250 to 218 deg. This factor in itself should apparently increase fuel consumption by the same percentage and should apparently tend to offset the 16 per cent gain previously credited. However, before debting this, consideration must be given to cylinder conditions as affected by back pressure.

A pound of saturated steam at the heater has a volume 1,200 times greater than a pound of water. The heater acts as a condenser with the result that steam is drawn from the cylinders by the heater, condensed therein, and its volume very considerably reduced. This continuous withdrawal of steam from the cylinders, thereby robbing the nozzle of some of its steam, reduces the back pressure.

Calculations of what this may amount to can be made, but would be very difficult and probably not very reliable. Indicator cards carefully taken so that the steam pressure, point of cutoff and speed are the same with and without the feedwater heater in use will give the true facts. Such cards are available. At speeds where the full boiler capacity is employed, it will be found that about six per cent more horsepower is developed at the same point of cutoff with the heater in use.

This value happens to coincide with the per cent increase in weight of steam per horsepower hour, resulting from reduced superheat. This six per cent greater weight of steam necessary on account of reduced superheat, bal-

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[*] From a Paper Read Before the New England Railroad Club.

ances the increased horsepower from reduced back pressure. Hence the weight of steam per horsepower-hour is not altered by the heater application. Therefore, no further consideration need be given these two features, so far as their effect on the firebox is concerned. However, the increased cylinder horsepower must be considered in a following paragraph with relation to its effect on train operation.

While there is no exact information available, there is undoubtedly a direct relation between the weight of steam discharged through an exhaust nozzle and the weight of gases discharged through the stack. A good steaming engine gives full boiler pressure at all speeds when the proper cutoff for the speed is used. With a feedwater heater there is about 14 per cent less weight of steam passing through the nozzle but there is about 16 per cent less weight of hot gases to be handled. It seems reasonable to assume, that at least at normal speeds, there should be no difficulty in maintaining a satisfactory vacuum in the smokebox with the same size nozzle, with and without the heater. Experience with a large number of heaters in service throughout the country indicates this to be true.

There will be no real change in the relation of indicated to drawbar horsepower. The weight of steam per indicated horsepower-hour will be the same because of the balancing of the effect of reduced superheat, and reduced back pressure. The heat in each pound of steam, however, will be less because of its lower temperature. This will amount to about 17 B.t.u. per lb. The effect of the heater on the terminal efficiency can be indicated with reasonable accuracy by comparing the pounds of steam produced with and without the heater for a definite amount of heat generated in the firebox.

Taking one million heat units in the fuel in both cases as an example, without the feedwater heater and at an overall boiler efficiency of 65 per cent, then 650,000 heat units appear in this steam. This steam has a temperature of about 640 deg. F. and is formed from water of 60 deg. temperature. There was thus added to each pound of steam about 1,307 heat units. The heat units available would supply 497 lb. of steam at 640 deg. temperature.

When the feedwater heater is applied, the boiler efficiency rises to 68 per cent. Of the one million units supplied, 680,000 units are now used. The steam has a temperature of about 608 deg. F., or 32 deg. lower and is formed from water entering at 220 deg. temperature. This requires the addition of but 1,130 units per pound instead of 1,307 and the heat available will supply 602 lbs. of steam, instead of 497.

It thus appears that when burning an amount of coal containing one million B.t.u., 497 lbs. of steam at 640 deg. will be delivered without a heater and 602 lbs. at 608 deg. with the heater. This gives 21 per cent more pounds of steam with the heater. As explained previously, the thermal efficiency will vary at the some rate as the weight of steam flow. It would appear from this that an increase in the thermal efficiency of over 20 per cent could be expected.

It has been shown that 14 per cent of the main engine exhaust is condensed in the heater and returned for boiler feed purposes. With a tender capacity of 10,000 gal., let us assume that the total water evaporated per hour is 5,000 gal. At full capacity, this tender full of water would last two hours on the locomotive without the heater in use.

With the heater in service and with 14 per cent of the main exhaust reclaimed as boiler feed, the balance, or 86 per cent, is drawn from the tender. At this rate, the tender full will last 2.32 hours, or 16 per cent longer.

If the steam exhausted from the locomotive auxiliaries, such as the air pump, feed pump, stoker engine, headlight generator, etc., is carried direct to the feedwater heater, and condensed therein, the 16 per cent increase in tender capacity will rise accordingly, probably on the order of one or two per cent. It is, therefore, apparent that reclaiming the exhaust steam in the heater as boiler feed is equivalent to a tender of 16 per cent or more greater capacity than without a heater.

Up to this point, the calculations are based on the locomotive working at full boiler capacity. Stand-by losses, reduced rates of speed and other such factors concerned with everyday operation, will lower the average boiler performance figure to some extent. It is safe to state that all of these factors combined will, in a great many cases, reduce the total savings by approximately 30 per cent when the average performance of the locomotive over the division is considered, rather than momentary performances at high rates of driving. The 30 per cent figure refers more particularly to freight operation than passenger service, where boilers are worked a greater proportion of the road time at full capacity.

The purpose of this analysis was to note the effect of feedwater heater applications on train operation. Obviously this requires consideration of charge in locomotive capacity, either in the form of increased speed or increased hauling power. It would appear that an investigation of this feature can best be made on the basis of burning the same amount of coal in a given time for the locomotive with and without the heater.

It has been shown that with due allowances for changes in superheat and back pressure, the weight of steam available for use at the cylinders is true index of the power available, because, the pounds of steam per indicated horsepower-hour is not changed with the application of the heater.

Therefore, on the basis of again using 1,000,000 heat units in the coal at the same rate in each case, the boiler efficiency will be essentially the same, or 65 per cent. Without the heater, each pound of steam requires the addition of 1,307 heat units per pound, while with the heater, only 1,130 units are required. The increase in weight of steam flow per hour is from 497 to 575 lb., or over 16 per cent. With the increased amount of steam available per hour, the question arises as to what can be expected in the form of increased speed.

Drawbar horsepower varies directly with the speed, and further, there is a constant relation between indicated and drawbar horsepower within range of this discussion so that it is safe to say that a comparison of the indicated horsepower in the two cases will give the answer.

The effect of the heater on back pressure has already been considered with both indicator cards take at the same speed. However, an increase in speed would increase to some extent the back pressure, and the gain from this feature will be somewhat reduced. Let it be assumed that the increase in speed cuts the 6 per cent gain in half. Consequently, 6 per cent more steam will only produce 3 per cent more work and the pounds of steam per indicated horsepower-hour will now be 3 per cent greater. On this basis, the 575 lb. of steam available must be reduced by 3 per cent resulting in 557 lb., which, referred to the 497 lb. of steam, is a net gain of 12 per cent. Consequently, with an increase in weight of steam flow per hour of 15 per cent, the increase in speed at the same drawbar pull is 12 per cent.

Consideration of a possible incease in drawbar pull can follow the same general line of reasoning as above, namely, on the basis of comparing the indicated horsepower.

For a greater drawbar pull, it is necessary to lengthen the point of cutoff. It indicator cards are available, calculations are easy. If not, comparison of water rates at the two points of cutoff will give a close approximation.

The increased total weight of steam flows with the heater gives steam at a different specific volume than without the heater. The 575 lb. of steam by weight at 608 deg. requires 11 per cent more volume than the 497 lb. of steam by weight at 640 deg. On this basis, the point of cutoff must be increased 11 per cent or, say, from 45 to 50 per cent of the stroke. A comparison of the resulting indicator cards shows an increase in water rate of about 4 per cent. On this basis, the 575 lb. of steam available must be reduced by 4 per cent or to 552 lb., which, referred to the 497 lb. originally available, is an increase of 11 per cent. Consequently, the 15 per cent increase in total available steam can produce 11 per cent greater drawbar pull at the same speed.

There are two ways of utilizing the benefits of the feed heater. The first one is to handle the situation entirely from the standpoint of feed economy. In this case, train loading is kept as before and the direct results are in terms of reduced fuel consumption. The increased tender capacity will take the form of either direct elimination of water stops, or will permit flexibility in selecting the more desirable stops; the increased horsepower should result in slightly faster running time; and the combined result should show reduced fuel and possibly greater ton-miles per train hour.

The other way is to develop greater earning capacity per locomotive with the same amount of fuel as before. The heater application permits development of either increased speed or increased drawbar pull at points where full boiler capacity has otherwise been reached. These factors are directly reflected in increased ton-miles per train hour or, in other words, the ability to handle more business per locomotive.

Prizes for Welding Papers

The Lincoln Electric Company, Cleveland, Ohio, will award, through the American Society of Mechanical Engineers at its 1928 spring meeting, prizes totaling $17,500 for the three best papers submitted in a competition on arc welding, the purpose of which is to encourage improvements in the art, the pointing out of new and wider applications of the process, or the indicating advantages and economies to be gained by its use. The competition, which will close on January 1, 1928, is open to anyone in any country of the world. The rules governing it may be obtained from Calvin W. Rice, secretary, American Society of Mechanical Engineers, 29 West Thirty-ninth st., New York. The prizes are $10,000, $5,000 and $2,500, respectively.

Internal Combustion Engines in Rail Transportation

By **A. H. CANDEE, Railway Engineer, Westinghouse Electric & Mfg. Co.**

The application of internal combustion engines to railway propulsion is merely the application to practice of basic economic principles. If we analyse the factors contributing to our present day civilization and prosperity it will be found that the application of efficient machines or tools to save human labor has been responsible in a large measure for this condition. Another factor is the efficient use of our natural resources. Further, a large measure of our present prosperity may be attributed to the division between labor and capital of the savings in labor by their proper use.

When we speak of machines and tools we naturally think in terms of factories and machine shops, but if you will consider it from a slightly different angle you will find that railroads are also manufacturers. Their product is ton-miles and passenger-miles. The measure of the effectiveness of the railroads as manufacturers is the sale price of their products as against the cost of production and they should therefore be interested in any tool which will increase the differential between price received and cost to produce. As a matter of fact, the individuals making up the organization should be especially interested because it is an economic fact that as a class their purchasing power can be increased only by greater production for a given amount of labor.

The railroads of this country have reached their tremendous proportions only by the use of that effective, reliable and spectacular tool—the steam locomotive. Were the steam locomotive less reliable and versatile than it is the growth of our nation would have been stunted and the west might still be wild and wooly. It is with a sense of pride and respect that we refer to our railroads as "steam" roads.

The present day steam locomotive is the result of 100 years of development, considerable of the detail refinement having occurred within the past decade. The future also holds promise of further improvement by the use of higher steam pressures, steam turbines and condensers. Any new form of motive power enters the field under very severe handicap and must be thoroughly tried and proven before it will be given serious consideration by the steam roads, so that the interest taken by the railroads in propulsion by means of the internal combustion engine is exceedingly encouraging to those who advocate this motive power.

The steam locomotive has lost the race for supremacy in some particular classes of service. I refer to electrifications such as the New York, New Haven and Hartford; Norfolk & Western; Virginian; Pennsylvania; Chicago, Milwaukee and St. Paul; Long Island and others. Here the operating economies and advantages have been proven beyond doubt. There are many other places in the country where electrification will do as much and show equal operating advantages, but for the large bulk of the present steam operated mileage the steam locomotive cannot yet be displaced.

It has been within our lifetime that the tremendous possibilities of liquid fuels have been realized. The application of the internal combustion engine to millions of highway vehicles, to ships and in stationary service has proven it to be a thoroughly effective and reliable tool. Yet considerable development and research work will be necessary before it can be generally adopted to replace steam locomotives. We are beginning to learn how to build light weight high speed engines, but there is still a great deal to do.

Gasoline and Diesel engines have already been applied in quantity for rail propulsion duty and have proven reliable and practical for rail car service at least. In this field the Patton Motor Car Co. built a car in 1890 powered with a small gasoline engine and electrical transmission. A gasoline car with mechanical transmission was built in Wurtenburg, Germany, in 1893 and a similar model was operated in Chicago in 1899. Extensive development was started in the motor car field in 1920 and 1901, led by the French Westinghouse Company. During that time the McKeen car, the Strang car and the General Electric car first appeared. In 1902 the first extensive application of gasoline driven cars was made by the French Westinghouse to the Arad-Csanad lines in Hungary, their number being supplemented from time to time until there were approximately 70 in operation in 1912. The latest reports indicate that of these there are approximately 50 still in serviceable condition.

The McKeen car with its mechanical form of transmission has survived and there are numbers still in operation today. The Strang car fell by the wayside, probably due to the fact that it was somewhat complicated by the use of a storage battery as a supplementary source of power. The General Electric car survived and approximately 88 of these were built. From available reports it is estimated that approximately 70 of these are are still in operation.

Due to war activities and our subsequent entry the gasoline car development slowed down and finally stopped from 1914 to 1920. It may be noted, however, that prior to the war the chief obstacles to unqualified success were due to engine designs.

The war brought about marked advances in engine designs. About 1920, with increased operating costs, the railroads reopened the question of gasoline rail cars and a number of light weight units were constructed. The first of these were simply highway trucks with flanged wheels instead of rubber tired wheels. These were light in weight and construction. Several modifications and improvements followed, but in general, the experience indicated the necessity of more power and heavier car construction, also that vry definite economies were effected.

The next major step was the construction of the Brill model 55 car. This conformed more closely to the ideas of the railroads and was found to be thoroughly practical for light branch line service. A very satisfactory form of mechanical drive had been worked out and this contributed materially to the success of the car.

A number of small cars sprang up almost overnight, but the demand for small cars had passed the zenith due to demands of the railroads for more power and trailer hauling capacity. Next the Brill brought out their models 65 and 75 with horse power as high as 190 and the Syke mechanical drive car appeared with its 175 horse power engine. The Electromotive Company then applied electrical transmission to a 175 horse power engine, while the Brill Company appeared with a 250 horse power engine with electrical transmission. Every one of these cars proved themselves reliable where properly applied.

There are between 450 and 500 gasoline driven rail cars now in operation in this country. It may be noted in passing that the electrical form of transmission has been selected for the large majority of all cars bought within the past two years.

The Diesel engine apparently appeared on a car in a commercial way in Sweden about 1913. Their use has not spread very rapidly in Europe as there are probably not more than 25 or 30 of these cars operating there at present. The first oil engined cars appeared on this continent in 1925 when the Canadian National Railways built two cars, each powered with a Beardmore 8 cylinder solid injection oil engine of 400 horse power capacity. This engine is a modification of the Beardmore air craft oil engine. These two were followed by seven cars each powered with 4 cylinder engines of half the capacity of the first engines. The success of these units has been such that they have recently placed an order with the Beardmore Company for 5 more engines of 6 cylinder size, 300 horse power capacity.

There have been numerous attempts to produce oil engined locomotives within the past seven years, but only in the smaller sizes have they met with any degree of success. In these sizes, however, they have proven the economies of this type of motive power. There are numerous large locomotives now proposed or under construction and the next two or three years will see some long strides taken. The locomotive field, however, holds greater promise for the manufacturer than the rail car, for where there is a possible demand for but 3,500 to 5,000 rail cars, there are 75,000 steam locomotives to replace if the steam men let us do it.

In considering the economies of the situation we have reliable operating results only on rail cars. Where steam train costs on branch lines vary from $0.75 to $1.50 per train mile, with an average of from $0.90 to $1.00 we find we can handle the service by gasoline engines at a train mile cost varying between $0.30 to $0.60 with an average approximating $0.36 to $0.40 including fixed charges. Oil engine driven trains will operate between $0.25 and $0.50 per train mile with an average of $0.33 to $0.35 also including fixed charges. In addition there are a number of indirect returns which are exceedingly difficult to evaluate, such as reduced right of way maintenance, reduction of attendant facilities and charges, and improved public relations.

The savings effected by rail car operation are due to saving in crew expense, saving in fuel, reduction of maintenance and attendant charges, and improved availability. The first of these gets right back to the economic principle of greater production per man. The original light weight car often saved its price within the first year and the modern cars usually require less than two years.

The thermal efficiency of the steam locomotive is admittedly low, averaging not over 6 percent at the rail. If it were not that we have an abundant coal supply we would have been forced to overcome this handicap long ago, but in spite of the apparently unlimited supply of this fuel we are handicapping posterity by this tremendous waste. France and other European countries are turning to electrification on account of coal costs. How long can we expect to feed our 70,000,000 steam locomotive horse power at the rate of six cents worth of actual work for every dollar in fuel.

The thermal efficiency of the gasoline engine power plant is considerably better than that of a steam locomotime, for we can get as high as 20 percent of the energy of the fuel at the rail. This, of course, does not mean that we can operate at one-third of the fuel expense for a given service because the cost per pound of fuel is considerably higher than that of coal.

The oil engine power plant as applied to rail propulsion will operate at an overall thermal efficiency as high as 25 percent. In addition, the present cost of fuel oil is such that we can save considerable in the total fuel expense by the use of the oil engine.

Comparing the steam locomotive with the internal combustion engine locomotive as to availability for service, statistics show that the average steam passenger locomotive operates 113 miles per day. This is the distance from Pittburgh to Altoona over the Pennsylvania. Average the daily trains and you will find that the run takes 3¼ hours. This, then, may be taken as the steam passenger locomotive's available time per day, whereas a locomotive with an internal combustion engine plant can easily average from 3 to 4 times this amount.

It is not generally feasible to apply existing standard engines to rail propulsion service. Engines used in automotive work are generally small and lack the necessary stamina. If an engine is found to possess the latter feature it is usually because it has been built for stationary work and is too heavy and large for tranportation purposes. It seems necessary, therefore, to design engines for this particular field of application. The speeds must be high to reduce cost and weight and yet reliability and long life are of paramount importance. If you will consider that a year of rail car service is equivalent to ten years' service for your automobile engine you may get a conception of the duty imposed in this field.

In the gasoline engine field, the knowledge necessary to build suitable units is available, but as the present production is small there are few engines on the market. In the oil engine industry, however, there has been very little accumulated experience suitable for the production of rail propulsion engines, where dimensions and weights are prime considerations. For stationary and marine purposes oil engine weights run from 60 pounds per horse power up, whereas for rail vehicle use they must weigh less than 45 pounds and preferable not over 20 pounds per horse power. Slow speeds are not tolerable because slow speeds mean increased weight in both engine and generator, resulting in further addition of weight and strength of car bodies or locomotive construction, thus pyramiding both cost and weight of the vehicle as a whole.

The general automotive field has been built up around the 4 cycle engine, the cylinders arranged in line or in "V." Air craft engines are following somewhat different forms, such as radial cylinder arrangements. The preferred form of the locomotive oil engine has not yet been defined, for while the present tendencies are toward the use of four cycle engines on account of the available knowledge and experience there are a number of very promising developments being undertaken in the two cycle field. Solid fuel injection is preferred to the air injection.

The transmission of energy from the engine to the wheels forms a broad subject in itself. In rail cars, when engine sizes were small and a single rear axle was used, the ordinary gear shift form of automotive transmission was sufficient and satisfactory. When weights increased to a point where it became necessary to drive through a 4 wheel swivel truck the mechanical drive became serious. The Brill Company accomplished this very satisfactorily by transmitting power to a set of gears in the truck bolster, driving the wheels from there, so that swivelling of the truck did not seriously affect the drive. In other cars engines were mounted directly on the truck in order to obviate the drive difficulties, in one case the gear shifting and clutch operations being controlled electro-pneumatically.

A mechanical transmission of large size is in use on the Lomonosoff locomotive in Russia. This utilizes magnetic clutches with the gears constantly in mesh. The Boston and Maine Railroad has recently placed an order for one of these 1,600 horse power mechanical drive locomotives to be built in Europe so that we should soon be able to get some first hand information as to the operation of this type of drive.

Hydraulic transmission has been tried several times with some degree of success, but at this time does not appear to have a very large field of application in rail service.

The electrical form of transmission embodies qualities which render it the most practical for railway propulsion, especially for engine sizes above 125 horse power. Below this power there are satisfactory mechanical transmissions and the advantages of the electrical form are discarded for the sake of cheap construction. The essential advantages which make the electrical transmission the most desirable are the smooth flow of power to the wheels regardless of tractive effort or speed, the flexibility of control and application of power, and the absence of rigid or troublesome mechanical connections between the spring mounted engine and the wheels.

The present limitations in the application of engine driven vehicles to rail service are imposed by the size of engine which may be applied to the vehicle. We would like to apply engines of two or three times the horse power capacity now used, but this is not economically possible on account of weight and cost. It is, therefore, essential that the utmost use be made of the engine which may be applied. The electrical transmission permits such utilization over a very wide range. Curves show that a 1,250 horse power locomotive with electrical transmission has better performance throughout than a 1,600 horse power locomotive with mechanical transmission, even though the losses in the mechanical transmission are claimed to be lower than those of the electrical drive.

To the mechanical man the electrical transmission may seem complicated and mysterious, but as a matter of fact is simple. The engine is directly coupled to a simple generator which furnishes power to propulsion motors geared to the axles. An auxiliary generator also driven by the engine furnishes power for exciting the field of the main generator and also for charging a small storage battery used for engine starting and car lighting. The control of power is also simple. With gasoline engines this is usually accomplished simply by varying the engine speed, automatic adjustment of the current and voltage being into the apparatus. With the oil engine, which does not have as wide a range of speed control, it is sometimes necessary to make a few generator field adjustments before raising the engine speed, but this involves very little complication and occurs automatically with movement of the throttle control lever.

There are, of course, numerous variations of these schemes of control and they merely demonstrate the extreme flexibility of the system. It may be stated, however, that electrical designers realize the importance to the railroads of electrical simplicity and are bending their efforts toward that end.

In the electrical system of power transmission as in any other system, the problem of the auxiliaries is troublesome. Pressure air for the brakes must be provided and also cooling air for the radiators. Batteries must be charged and in some cases heat and light provided for trailing cars. It is these auxiliaries which cause a large part of the apparent complication in the self-propelled vehicle and yet these auxiliaries must be provided for, whatever the system of transmission employed.

In the application of engined cars or locomotives to rail service we first face the fact that we are dealing with limited power. We find that rail cars of 250 horse power are called upon to handle services formerly handled by steam locomotives of 800 to 1,000 horse power capacity and they can often do it surprisingly well. It is also found that in a great many cases the railroads call for cars which can reach a balancing speed considerably in excess of that required to handle any normal branch line service. The psychological effect of being able to attain a 60 mile per hour speed is wonderful but it imposes restrictions on the trailer capacity.

In an electrification project the service duty imposed upon the electrical equipment can be accurately calculated and adhered to. In the case of the internal combustion vehicle, though, it is necessary to design for general service and a wide variety of conditions such as may confront steam locomotives. This means that equipment size is often in excess of that required for specific applications.

No reference has been made to the internal combustion engine as applied to highway vehicles in railway service. It is well recognized that both the bus and the truck are now very important adjuncts to rail transportation. Undoubtedly their use will expand considerably, for, after all, the real business of the railroads is transportation, whether by rail, water or highways, and by proper coordination of such systems the best interests of the nation will be served.

In closing, let us review briefly the motive power situation as it appears to be developing. In the first place, the steam locomotive is not seriously threatened in the near future, but its position will depend upon the rate of progress which its designers can provide. It will be supplanted in a number of places by electrification, because the latter can show economies of operation which cannot be attained by steam or the internal combustion engine. The latter will undoubtedly supplant steam in the near future on light traffic lines, in yard switching service and where fuel and water are hard to obtain. Beyond that developments and service will govern its expansion in the locomotive field.

Notes on Domestic Railroads

Locomotives

The Chicago & Northwestern Railway has ordered one 60-ton Diesel electric switching locomotive from the Ingersoll-Rand Company, the American Locomotive Company and the General Electric Company.

The Erie Railroad contemplates buying about 50 locomotives in the near future.

The Apalachicola Northern Railroad has ordered from the American Locomotive Company, one 4-6-0 type locomotive. This locomotive is to have 19 by 26-in. cylinders and a total weight in working order of 136,000 lbs.

The Sorocabana Railway, South America, has ordered 10 three-cylinder Mountain type locomotives from the American Locomotive Company. These locomotives have 18½ by 22 in. and 18½ by 24 in. cylinders and a total weight in working order of 199,000 lbs.

The Central Railroad of New Jersey has been inquiring for 15 locomotives.

The Chicago & Northwestern Railway has ordered 12, 2-8-4 switching type locomotives from the American Locomotive Company.

The New York, New Haven & Hartford Railroad has ordered from the American Locomotive Company 6 three-cylinder eight-wheel switching locomotives. These locomotives are to have 22 by 28-in. cylinders and a total weight in working order of 246,000 lbs.

The New York Central Railroad is inquiring for 30 passenger type locomotives and 6 heavy eight-wheel switching locomotives.

The Texas & Pacific Railway has been getting prices on 5 switching type locomotives and 15 road locomotives of 2-8-4 type.

The Chicago & Northwestern Railway recently placed orders with the American Locomotive Company for 8 switching type locomotives.

The Southern Pacific Railroad has ordered from the American Locomotive Company 10 three-cylinders, 4-10-2 type locomotives. These locomotives are to have 25 by 28 in. and 25 by 32 in. cylinders and a total weight in working order of 445,000 lbs.

The Texas & Pacific Railway has ordered from the Baldwin Locomotive Works 5 eight-wheel switching type locomotives and from the Lima Locomotive Works 15, 2-10-4 type locomotives.

The Central Railroad of New Jersey is inquiring for 5 Pacific type locomotives and 10 eight-wheel switching locomotives.

The Oliver Iron Mining Company has ordered 10 heavy eight-wheel switching locomotives from the Lima Locomotive Works.

The Youngstown & Northern Railroad has ordered 2 six-wheel switching locomotives from the American Locomotive Company.

The Monongahela Railway is inquiring for 6 Mikado type locomotives.

The Boston & Maine Railroad is inquiring for 10 eight-wheel switching locomotives.

The Delaware, Lackawanna & Western Railroad is inquiring for 10 mountain type freight locomotives and 5 mountain type passenger locomotives.

The Ft. Smith Subiaco & Rock Island Railroad is inquiring for one consolidation type locomotive.

The American Metal Company of Mexico is inquiring for one six-wheel switching type locomotive.

Passenger Cars

The Southern Pacific Railroad has ordered 20 72-ft. coaches, 5 2-compartment 72-ft. coaches and 5 72-ft. interurban coaches from the Standard Steel Car Company, and 30 70-ft. baggage cars, 5 70-ft. baggage and mail cars and 5 baggage horse cars from the Bethlehem Steel Company.

The Santa Fe Railway has recently placed orders for 2 dining cars with Pullman Car & Manufacturing Company.

The Central Railroad of New Jersey is inquiring for 25 coaches.

The New York, New Haven & Hartford Railroad has ordered 6 73-ft. gas-electric rail motor cars from the J. G. Brill Company, Philadelphia, Pa.

The New York Central Railroad has ordered the following gas-electric motor cars for use on their road: 8 from the J. G. Brill Company, Philadelphia; 3 from the Osgood-Bradley Car Company; 2 from the American Car & Foundry Company and 2 from the Standard Steel Car Company.

The Wabash Railway has ordered 2 steel coaches from the American Car and Foundry Company.

The Alaska Railroad has placed orders for one gas-electric motor car and one trailer 51 ft. long with the J. G. Brill Company, Philadelhpia, Pa.

The Central Vermont Railway has ordered 2 combination passenger and baggage gasoline-electric rail motor cars and one combination baggage and mail trailer car from the J. G. Brill Company, Philadelphia, Pa.

The Richmond, Fredericksburg & Potomac Railroad has ordered one dining car from the Pullman Car & Manufacturing Corporation.

The Chicago, Springfield & St. Louis Railroad has ordered one combination passenger and baggage gasoline rail motor car and one combination baggage and mail trailer car from the J. G. Brill Company, Philadelphia, Pa.

The New York Rapid Transit Corporation has been getting prices on 150 subway car bodies.

The New York Central Railroad is inquiring for 121 passenger train cars, including 22 coaches, 10 suburban cars, 10 steel motor passenger car bodies, 3 combination passenger and baggage cars, 5 mail and baggage cars, 30 baggae cars, 10 baggage horse-cars, 30 milk cars, and one steel motor baggage car body.

The Wabash Railway has ordered 6 combination passenger and baggage cars from the St. Louis Car Company, 6 combination passenger and baggage cars, 10 chair cars and 8 coaches from the American Car & Foundry Company; 6 dining cars, 2 cafe cars and 4 lounge cars from the Pullman Car & Manufacturing Corporation.

The Northern Pacific Railway has ordered 3 72-ft. mail, baggage and passenger gas-electric motor cars equipped with power plants from the Electro Motive Company.

The Southern Pacific Railroad has been inquiring for prices on 75 cars for passenger train service.

Freight Cars

The Delaware, Lackawanna & Western Railroad is inquiring for 20 milk cars, 10 express cars and 2 combination mail and baggage cars.

The New York Central Railroad is inquiring for 1,000 box cars of 55 tons capacity, 1,000 steel hopper cars of 70 tons capacity, 1,000 steel gondola cars of 70 tons capacity and 500 steel gondola cars of 55 tons capacity.

The Atchison, Topeka & Santa Fe Railway has ordered 150 caboose cars from the American Car & Foundry Company.

The Western Electric Company is inquiring for 3 composite gondola cars.

The Standard Oil Company of New Jersey has ordered 10 all-steel box cars of 50 tons capacity from the Pressed Steel Car Company.

The Norfolk & Western Railway has awarded a contract for rebuilding 1,000 hopper cars of 57½ tons capacity to the Ralston Steel Car Company.

The Santa Fe Railway has been in the market for 150 caboose cars.

The Great Northern Railway has ordered 500 steel underframes for automobile cars from the Pressed Steel Car Company.

The Chicago & Illinois Midland Railway is inquiring for bids on repairing 240 gondola cars.

The Great Northern Railway has ordered 6 trunnion type air dump cars from the Pressed Steel Car Company.

The Missouri Pacific Railroad is inquiring for 300 box cars.

The Carbide & Carbon Chemical Corporation, New York City, has ordered 10 tank cars from the General American Tank Car Corporation.

The Clarendon & Pittsford Railroad is inquiring for 10 flat cars of 50-tons capacity.

The Southern Pacific Railroad is inquiring for 75 box cars.

The Northern Pacific Railway has ordered 200 ballast cars from the Rodger Ballast Car Company.

The Baltimore & Ohio Railroad is inquiring for 500 gondola car bodies of 50-tons capacity.

The Union Carbide Company, Niagara Falls, has ordered 4 hopper bottom ore cars of 50-tons capacity from the American Car & Foundry Company.

The Union Tank Car Company is inquiring for 500 tank cars of 8,000-gal. capacity.

The Dick Construction Company, Hazleton, Pa., has ordered 12 dump cars from the American Car & Foundry Company.

The Cambria & Indiana Railroad is inquiring for bids on repair of 300 hopper cars of 50-tons capacity.

The Missouri Pacific Railroad is now inquiring for 300 box cars.

The International Harvester Company is inquiring for 30 quadruple side dump cars.

The Cornwall Railroad is in the market for 15 hopper cars of 75-tons capacity.

The Union Railroad is having repaired at the shops of the Greenville Steel Car Company, 670 hopper cars.

The Eastman Kodak Company has ordered one 8,000-gallon special tank car from the General American Tank Car Corporation.

The Wheeling Steel Corporation, Wheeling, W. Va., has ordered 4 air-dump cars from the Magor Car Corporation.

The Pacific Fruit Express Company has ordered 89 steel frame refrigerator cars from the Pacific Car & Foundry Company.

The Detroit Edison Company has ordered one transformer transfer car from the Pressed Steel Car Company.

The General Electric Company has ordered 10 steel underframe flat car bodies from the American Car & Foundry Company.

The Minneapolis, St. Paul & Sault Ste Marie Railway has ordered 84 caboose car underframes from the Standard Steel Car Company.

The Pere Marquette Railway is inquiring for 20 air dump cars.

The St. Louis Southwestern Railway is inquiring for 30 steel underframes for caboose cars.

The Denver & Rio Grande Western Railroad has ordered 300 automobile cars of 40-tons capacity from the Mt. Vernon Car Manufacturing Company.

The Mid-Continent Petroleum Corporation has ordered 8 tank cars of 8,000-gallon capacity from the American Car & Foundry Company.

The Southern Railway is inquiring for 20 all-steel air dump cars of 30-yd. capacity equipped with extension sides or aprons.

The New York Central Railroad is contemplating the purchase of about 4,500 freight cars, including flat cars and 30 caboose cars. This is in addition to the 3,500 freight cars.

The Chicago Great Western Railroad is inquiring for 5 caboose cars.

The Delaware, Lackawanna & Western Railroad is inquiring for 500 box cars and 300 coal cars.

Buildings and Structures

The Chicago, Indianapolis & Louisville Railway has awarded a contract for the construction of a brick and steel locomotive repair shop at Lafayette, Ind., to cost approximately $275,000.

The Southern Pacific Railroad plans the construction of a locomotive repair shop at Eugene, Ore., at cost of approximately $220,000.

The Elgin, Joliet & Eastern Railway has awarded a contract for the construction of a one-story brick and concrete dormitory at South Chicago, Ill., to cost approximately $25,000.

The Cleveland, Cincinnati, Chicago & St. Louis Railway has awarded a contract for the construction of a 500-ton four-track electrically operated reinforced concrete coaling station at Riverside, Ohio.

The Baltimore & Ohio Railroad has awarded a contract for the construction of a 600-ton four-track electrically operated reinforced concrete coaling station, also two three-track electrically operated cinder handling units at Ohio.

The Chicago, Burlington & Quincy Railroad has awarded a contract for the construction of a one-story pattern storage building at West Burlington, Iowa, estimated to cost approximately $15,000.

The Canadian National Railways has awarded a contract for the construction of a 300-ton reinforced concrete coaling station at Belleville, Ont.

The Oregon, Washington, Railroad & Navigation Company plans the construction of a mill for boring and stamping new ties at the tie treating plant at Dalles, Ore.

The Chesapeake & Ohio Railway has awarded a contract for the construction of water treating plants and pumping stations at Ruble, Ohio, to the Railroad Water & Coal Building Company, Chicago, Ill.

The Chicago & Northwestern Railway has awarded a contract for the construction of a combined freight and passenger station at Land O'Lakes, Wis.

The Boston & Maine Railroad has awarded a contract for the construction of a new fruit exchange building at Boston, Mass., which will cost approximately $350,000.

The Delaware, Lackawanna & Western Railroad has awarded a contract for the remodeling and enlargement of the lunch room in the Hoboken Terminal at Hoboken, N. J., to cost approximately $50,000.

The Maine Central Railroad has awarded a contract for the construction of mechanical coal handling plant at Calais, Me., also for the construction of a 50,000-gallon capacity water tank. The total cost of both is estimated at about $40,000.

The Minneapolis, St. Paul & Salt Ste Marie Railway has plans for the enlargement of the Schiller yard at Chicago, Ill., to cost approximately $625,000 which include terminal improvements.

The Wabash Railway plans the construction of a 10-stall roundhouse, a 100-ft. turntable, a water tank and a trainmen's service building at Ft. Wayne, Ind., to cost approximately $200,000.

The Southern Railway plans the construction of reinforced concrete coaling stations at Monroe, Va., 1,000 tons capacity; 1,000 tons capacity at Columbia, S. C.; 375-tons and 225-tons capacity at Bull Gap, Tenn., 800-tons capacity at Atlanta Junction, Ga., 500-tons at Coster, Tenn., 500-tons at Sheffield, Ala., 200-tons and 300-tons at Anniston, Ala., and for 300-tons at Lawrenceville, Va., Winston, Salem, N. C., and Jacksonville Fla.

The Chicago Indianapolis & Louisville Railway plans to build an addition 76 by 411 ft. to its machine shop at Lafayette Ind.

The Pensylvania Railroad has awarded a contract for the construction of a simplex automatic electric coal handling plant at South Amboy, N. J., to Roberts & Schaefer Company, Chicago, Ill.

The Chicago, Burlington & Quincy Railroad plan the construction of a water treating plant at Akron, Colo.

The Pittsburgh & West Virginia Railway has awarded a contract for the construction of a machine shop at Rook, Pa., which will cost approximately $150,000.

The Atlantic Coast Line Railroad has awarded a contract for the construction and installation of a junior "N & W" type cinder handling plant at Piners Point, Va., to the Roberts & Schaefer Company, Chicago, Ill.

The Indiana Harbor Belt Railroad has awarded a contract for the construction of a junior "N & W" type combined engine coaler and cinder handling plant at Argo, Ill., to the Roberts & Schaefer Company, Chicago, Ill.

The Baltimore & Ohio Railroad is making plans for improving its terminal facilities at Philadelphia, Pa.

The Missouri Pacific Railroad has plans for the construction of a reinforced concrete automatic electric coaling station at Osawatomie, Kan.

The Norfolk & Western Railway has awarded a contract for the construction of buildings in car repair yard at Portsmouth, Ohio, to cost approximately $30,000.

The New York, New Haven & Hartford Railroad has awarded the contract for the installation of two sand handling and drying plants at Lowell and Fall River, Mass.

Supply Trade Notes

The Equipment Sales Corporation, Railway Exchange building, St. Louis, Mo., has been appointed sales representative for the **Flannery Bolt Company,** Pittsburgh, Pa.

The **S K F Industries, Inc.,** formerly of 165 Broadway, New York City, are now located at their new offices at 40 East Thirty-fourth street, New York City.

William T. Kilborn, assistant sales manager of the **Graham Bolt & Nut Company,** Pittsburgh, Pa., has been appointed general sales manager.

Henry M. Robinson, president of the First National Bank of Los Angeles, was elected a director of the **General Electric Company** at the meeting of the board in New York on March 25. In addition to his position with the First National Bank, Mr. Robinson is president of the First Securities Company, chairman of the board of the Pacific Southwest Trust and Savings Bank, and a director in a number of other large corporations. This is the first time the General Electric Company has gone to the West for a member of its board.

Norman M. Hench has been appointed sales engineer tract accessories, rail bureau of the general sales department for the **Illinois Steel Company,** Chicago, Illinois.

The **Linde Air Products Company,** 30 East 42nd St., New York, are planning the construction of two new plants, one at Duluth, Minn., and the other at Houston, Texas.

The **Pittsburgh Testing Laboratory** has removed its New York City Office and Laboratory from 50 Church St. to 72 Washington St.

J. H. Coyle, supervisor of engineering of the **Billings & Spencer Company,** with headquarters at Hartford, Conn., is now in charge of sales engineering in New York, Pennsylvania and New England. Mr. Coyle's headquarters will remain at Hartford, Conn.

David H. Moore, electrical engineer and assistant to the secretary of the **Ohio Brass Company** since the fall of 1925, has been appointed district sales manager with headquarters at 50 Church St., New York City.

J. J. Hennessey, Superintendent of the Railway sales division of the **Texas Company,** with headquarters at New York, has resigned to go into other railway sales work, with headquarters at New York.

George F. Konold, Jr., secretary of the **Warren Tool & Forge Company,** Warren, Ohio, has been elected president to succeed **James D. Robertson,** deceased.

The **American Chain Company** of Bridgeport, Conn., is planning to build a plant on the Pacific Coast to supply the western trade. **Walter B. Lashar,** head of the company, stated recently that competition of German exporters on the coast led to the investigation of the possibilities of a branch plant there. The American Chain Company is moving certain of its departments from the Bridgeport plant to the branch at York, Pa. The heavy production department is now being moved.

C. F. Hopkins has been appointed assistant to the president of the **E. A. Lundy Company, Inc.,** Pittsburgh, Pa.

E. S. Wortham, sales agent of the Scullin Steel Company, with headquarters at Chicago, has been promoted to vice-president with the same headquarters.

The **National Railway Appliances Association** has moved its offices, including those of C. W. Kelly, secretary and treasurer, to the Oliver Building, Chicago, Ill.

Gordon Stoner, Secretary of the **Midland Steel Products Company,** Cleveland, Ohio, and manager of its Detroit plant, has been elected vice-president, with headquarters at Detroit, succeeding **H. F. Kulas.**

W. A. Slack, president of the **Torchweld Equipment Company,** has been on an extended business trip on the Pacific Coast for the last five weeks.

The scale business of the **Fairbanks Company** of New York has been acquired by purchase by **Fairbanks, Morse & Company,** Chicago, Ill.: **W. S. Hovey,** vice-president and general manager of **Fairbanks, Morse & Company,** has been elected president and general manager, succeeding **C. H. Morse,** who has been elected chairman of the board of directors.

H. W. Renick, Pacific Coast representative of the **Ramapo Ajax Corporation,** with headquarters at Los Angeles, Calif., has been elected vice-president in charge of the newly opened plant at Los Angeles, to be known as the **Racor Pacific Frog & Switch Works. W. P. Janicki,** formerly assistant chief engineer of the Chicago plant, has been appointed district engineer and superintendent of the newly opened plant at Los Angeles, Calif.

Maurice L. Sindeband has been elected a vice-president of the **American Brown Boveri Electric Corporation,** with headquarters at New York.

Ernest L. Estes, connected with the railway sales department of the **E. I. duPont de Nemours & Company,** with headquarters at Parlin, New Jersey, has been appointed district manager of railway sales, with headquarters at St. Paul, Minn.

The **Martindale Electric Co.,** Cleveland, Ohio, announces that effective February 21, their new address is: 1260 West 4th St.

F. A. Weymouth, formerly of the **Bethlehem Steel Company,** has been elected vice-president of the **Burden Iron Company,** with headquarters at Troy, N. Y.

The Stoody Welding Company of Whittier, Cal., is planning to enlarge its present plant by the construction of a new one-story building, which will provide 1,600 additional square feet of floor space.

R. C. Violett, formerly division engineer of the Denver & Rio Grande Western Railroad with hearquarters at Pueblo, Colo., has been appointed representative of the **American Fork & Hoe Company,** with headquarters at 520 East Fourteenth Ave., Denver, Colo.

John R. Hayward will succeed **Frank N. Grigg** of Washington, D. C., as Southeastern railway sales manager of the **Heywood-Wakefield Company,** Wakefield, Mass. Mr. Hayward's headquarters will be at Liberty Trust Building, Roanoke, Va.

Excelo is the trade name of a brand of welding rods in standard sizes, recently announced by **E. B. Giberson & Co.,** 40 Rector St., New York City.

Joshua A. Hatfield has been elected president of the **American Bridge Company** with headquarters at New York, succeeding August Ziesing, retired. **L. A. Paddock,** president of the **Canadian Bridge Company,** has been elected a vice-president and **F. B. Thompson** has been elected a vice-president.

W. H. Norton, representative of the **Link-Belt Company,** has been appointed manager of the Sales office opened at 229 Brown-Max Building, Birmingham, Ala.

H. K. Williams, commercial engineer in the Northeastern district sales office of the **Safety Car Heating & Lighting Company,** with headquarters at New York, has been appointed sales engineer, with same headquarters.

The **Magnetic Signal Company** has moved its general office and plant to 3355 East Slauson Ave., Los Angeles, Calif.

J. M. Lorenz, vice-president and manager of railroad sales of the **Central States General Electric Supply Company,** has resigned to become vice-president and director of sales of the **Ralco Manufacturing Company,** with headquarters at Chicago, Ill.

The **Prest-O-Lite Company** of New York City is making arrangements for the construction of a new $80,000 plant at Birmingham, Ala.

H. A. Cronmiller has been appointed representative of the **O. M. Edwards Company, Inc.,** with headquarters at 412 Broadway, New York City, to succeed **A. J. Horgan.**

A. R. Chalker, chief draftsman of the **Locomotive Stoker Company,** has been appointed mechanical engineer with headquarters at Pittsburgh, to fill the vacancy caused by the death of **L. E. Osborne.** Mr. Chalker received his education at Boardman Manual Training High School and his technical training at Yale University, having been graduated from Sheffield Scientific School in 1906. He was formerly employed by the **Baldwin Locomotive Works** and the **General Electric Company.** In 1911 he entered the employ of the Locomotive Stoker Company and was appointed chief draftsman in 1916. **C. R. Davison,** who has been doing special engineering and designing work in the engineering department since 1917, has been appointed chief draftsman with headquarters at Pittsburgh, to succeed **Mr. Chalker.**

The Pullman Car & Manufacturing Corporation has purchased a controlling interest in the **Dickson Car Wheel Company,** Houston, Texas.

A. H. Elliot of the **American Brake Shoe & Foundry Company,** New York, has been elected a vice-president of the **Southern Wheel Company,** with headquarters at New York City. The Southern Wheel Company is a subsidiary of the American Brake Shoe & Foundry Company.

The Pittsburgh office and laboratories of the **Robert W. Hunt Company** have been removed from the Monongahela building to the Professional building, Pittsburgh, Pa.

Thomas L. Mount, manager of the car lighting department of the **Electric Storage Battery Company,** at **Philadelphia,** has established the firm of the **Thomas L. Mount Company,** with headquarters at 136 Liberty street, New York City, for the purpose of servicing and selling electrical supplies to the railroads.

J. G. Carruthers, sales manager of the **Otis Steel Company,** has been elected vice-president. **G. A. Paine** has been appointed treasurer, to succeed **L. Kemper,** resigned. **J. W. Carpen** has been appointed assistant secretary-treasurer.

Items of Personal Interest

George A. Silva, general inspector of locomotive maintenance of the Boston & Maine Railroad with headquarters at Boston, Mass., has been appointed superintendent of shops, with headquarters at North Billerica, Mass., succeeding **H. L. Leighton.**

J. A. Brossart has been appointed general master car builder of the Cleveland, Cincinnati, Chicago & St. Louis Railway with headquarters at Indianapolis, Ind., succeeding **I. S. Downing**, deceased.

William Keiser, general enginehouse foreman of the Indiana Harbor Belt Railroad with headquarters at Blue Island, Ill., has been promoted to the position of master mechanic with headquarters at Gibson, Ind.

G. W. McGowan, shop superintendent on the Texas lines of the Southern Pacific Railroad with headquarters at Houston, Texas, has been appointed master mechanic of the Houston terminals, including jurisdiction over the Englewood car department.

Henry H. Urbach, assistant superintendent of motive power of the lines of the Chicago, Burlington & Quincy Railroad east of the Missouri River with headquarters at Chicago, has been promoted to superintendent of motive power lines west with headquarters at Lincoln, Neb.

J. P. Christiansen has been promoted to the position of mechanical engineer of the Chicago, Indianapolis & Louisville Railway with headquarters at Lafayette, Ind.

Joseph H. Duke has been appointed assistant roundhouse foreman of the Southern Railway with headquarters at Valdosta, Ga.; **Earl T. Heree** has been appointed roundhouse foreman with headquarters at Macon, Ga., succeeding **Robert P. Balkcon.**

J. T. Connor, master mechanic of the Houston division of the Southern Pacific Railroad with headquarters at San Antonio, Texas, has been appointed shop superintendent at Houston, succeeding **G. W. McGowan.**

J. W. Cyr, of the Chicago, Burlington & Quincy Railroad has been appointed superintendent of shops at Aurora, Ill., succeeding **J. A. Carney** who has been appointed acting superintendent of safety with headquarters at Chicago, Ill., succeeding **D. E. Hahn.**

O. C. Wright has been appointed master mechanic of the Pennsylvania Railroad with headquarters at Indianapolis, Ind., succeeding **W. R. Davis,** transferred to Meadows, New Jersey.

F. L. Carson, assistant superintendent of motive power of the Southern Pacific Railroad with headquarters at Yoakum, Texas, has been transferred to San Antonio with supervision over shops and all mechanical matter on the Houston division.

James S. Clarke, of the Boston & Maine Railroad, has been appointed general inspector of locomotive maintenance with headquarters at Boston, Mass., succeeding **George A. Silva.**

Charles Eddington, division foreman of the Santa Fe Railway with headquarters at Phoenix, Ariz., has been appointed to general foreman with headquarters at Winslow, Ariz.

Malcolm Morrison, division car foreman of the Boston & Maine Railroad with headquarters at Concord, N. H., has been appointed general inspector car department with headquarters at Portland, Maine.

George H. Logan has been appointed superintendent of the Chicago & Northwestern Railway locomotive shops at Chicago, Ill., succeeding **J. Murrin,** retired on the pension list.

I. B. Chadwick has been appointed superintendent of the New York Central Railroad with headquarters at Charleston, W. Va.

H. F. Derner, general foreman car department of the Indiana Harbor Belt Railroad with headquarters at Gibson, Ind., has been appointed general inspector car department of the Boston & Maine Railroad with headquarters at Boston, Mass.

Arthur Carr has been appointed road foreman of engines of the Pacific lines of the Southern Pacific Railroad with headquarters at Dunsmuir, Calif., succeeding **W. C. Davis.**

W. C. Davis has been appointed road foreman of engines of the Southern Pacific Railroad with headquarters at Tracy, Calif., succeeding **G. B. Jefferies.**

William C. Lang has been appointed master car builder of the Pittsburgh & Lake Erie Railroad with headquarters at McKees Rocks, Pa.

A. Buryn has been appointed assistant boiler shop foreman of the Chesapeake & Ohio Railroad with headquarters at Huntington, W. Va.

W. G Fifield, assistant road foreman of engines on the Coast division of the Southern Pacific Railroad with headquarters at San Francisco, Calif., has been appointed road foreman of engines at the same point, succeeding **M. I. King.**

J. A. McGinnis has been appointed machine shop foreman of the Santa Fe Railway with headquarters at Slaton, Texas.

David C. Reid has been appointed superintendent of locomotive maintenance of the Boston & Maine Railroad with headquarters at Boston, Mass.

Charles W. Quinn has been appointed mechanical inspector of the Boston & Maine Railroad with headquarters at Boston, Mass., succeeding **James S. Clarke.**

P. M. Allen, chief general signal inspector of the New York Central Railroad with headquarters at Albany, N. Y., has been appointed trainmaster on the Pennsylvania division with headquarters at Corning, N. Y.

Richard K. Bradford has been promoted to superintendent of transportation of the Denver & Rio Grande Western Railroad with headquarters at Denver, Colo.

I. H. Luke, general manager of the Denver & Rio Grande Western Railroad with headquarters at Denver, Colo., retired on April 1. **A. C. Shields** succeeds Mr. Luke.

T. Joseph Jelbart has been appointed superintendent of passenger transportation of the Pennsylvania Railroad with headquarters at Pittsburgh, Pa.

H. B. Mitchell, assistant general manager of the Wisconsin & Michigan Railway, with headquarters at Menominee, Mich., has been appointed general manager.

George D. Dixon, assistant to the president of the Pennsylvania Railroad, with headquarters at Philadelphia and formerly vice-president in charge of traffic, has retired in accordance with the pension regulations of the company.

A. Ewing, superintendent on the Western lines of the Atchison, Topeka & Santa Fe Railway, with headquarters at Las Vegas, N. M., has been appointed to assistant general manager of the Western district of the Eastern lines, with headquarters at Topeka, Kan., succeeding **D. S. Farley,** transferred to the Eastern district, with the same headquarters.

Obituary

Alvah Seymour Going, terminal engineer of the Canadian National Railways, with headquarters at Montreal, Canada, died on March 21. He was born April 7, 1860, at Portland, Ore., and was educated at Lafayette College. Entered railway service June, 1880, as instrumentman Oregon Railyay & Navigation Company, since which he has been consecutively, 1881 to 1883, assistant engineer Northern Pacific Railway; 1884 to 1886, assistant engineer Oregon Pacific Railway; 1887 to 1888, resident engineer Seattle Lake Shore & Eastern Railway; 1888 to 1889, resident engineer Northern Pacific Railway; 1890 to 1902, in private practice in State of Washington and British Columbia; 1903 to 1904, division engineer Great Northern Railway lines in British Columbia; 1904 to 1905, exploratory engineer Grand Trunk Pacific Railway for British Columbia; 1905 to 1907, division engineer Minneapolis & St. Louis Railway; 1907 to 1912, locating engineer in charge of surveys, reports, etc., Grand Trunk Railway; December 1, 1912, Mr. Going served as locating engineer in charge of surveys, reports, etc., for the Grand Trunk Railway, and on December 1, 1912, became engineer of construction of that road, which is now a part of the Canadian National Railway, with headquarters at Montreal. In May, 1923, he was appointed terminal engineer of the Canadian National Railways, which position he held until his death.

Frank B. Philbrick died at his home in Waterville, Me., January 31, 1927. He was born in Waterville in 1848 and received his education in the local schools and in New York City. His early work was done in the Baldwin Locomotive Works of Philadelphia, Pa., and the Maine Central Railroad Shops in Waterville, Me. He formed a partnership with Frank B. Webber and Charles T. Haviland in 1873 in a foundry and machine shop. The business was later incorporated as the Waterville Iron Works, Mr. Philbrick serving as president and engineer. At the time of his death he was actively engaged in the work of this company.

Irving Williams, representative of the William Sellers & Company, Inc., Philadelphia, Pa., died at his home in Harrisburg, Pa., on March 11. Mr. Williams was graduated as a mechanical engineer at the Massachusetts Institute of Technology. He entered the employ of the Pennsylvania Railroad as special apprentice and was later promoted to various positions until he was appointed master mechanic. In 1925 he became associated with the injector department of William Sellers & Company, Inc.

George H. Bremner, formerly a district engineer on valuation for the Interstate Commerce Commission and for over 16 years Treasurer of the American Railway Engineering Association, died on April 3 after a long illness. Mr. Bremner was born on December 17, 1861, at Marshalltown, Iowa, and graduated from the University of Iowa in 1883, entering railway service in 1880 on the Chicago, Burlington & Quincy Railroad. He served as a rodman on the construction of the Chicago, St. Paul & Kansas Railroad until 1884. He acted as a transitman on maintenance of way on the Chicago & Northwestern Railroad and also as transitman in charge of the location of the St. Louis, Keokuk & Northwestern Railroad. He was then appointed assistant engineer of maintenance of way of the Chicago, Burlington & Quincy Railroad with headquarters at Chicago. From 1902 to 1915 he was engineer of maintenance of way of the Illinois district, when the became assistant district engineer, Central district, division of valuation of the Interstate Commerce Commission. In 1922 he was appointed to the engineering staff of the Chicago, Burlington & Quincy Railroad, retiring in 1924 due to illness. Mr. Bremner served continuously as treasurer of the American Railway Engineering Association from 1911 until 1927.

J. H. Burwell died on March 16 at his home in New York City at the age of 81 years. He was in the railroad supplies business at Grand Central Terminal, New York City. He was born in Franklin, Ohio, and in his earlier years was one of the firm of Mast, Burford & Burwell, manufacturers of farm implements at Fargo, Ill. In 1890 he opened an office in the East, selling railroad supplies up to the time of his death. Mr. Burwell represented the Pillod Company, Swanton, Ohio., the Q. & C. Company, New York, and the Graham, White, Sander Corporation, Roakoke, Va.

John Mackenzie, retired superintendent of motive power of the New York, Chicago & St. Louis Railroad, died March 19, in St. Petersburg, Florida. Mr. Mackenzie was born September 22, 1844, in Scotland. Entered railway service in 1859. In 1883 was appointed superintendent of motive power. Mr. Mackenzie was past president of the Central Railway Club and was also past president of the Master Mechanics Association. He was instrumental in drafting and adopting of the present rule of interchange by the master mechanics and master car builders quite a few years ago.

New Publications

Books, Bulletins, Catalogues, etc.

The Oxwelder's Manual—The Oxweld Acetylene Company have just published the new edition of the Oxwelder's Manual. It is known as "Manual of Instruction." It covers the entire subject. All students and officials will derive much interest from a perusal of the pages of this volume. The various subjects covered are: Historical Development of Oxy-Acetylene Welding; Oxygen and Acetylene; The Process of Oxy-Acetylene Welding and Cutting; Equipment for Welding and Cutting; Blowpipes—Construction and Operation; Regulators—Construction and Operation; Welding Sheet Steel; Welding Steel Plate; Welding Steel Pipe; Welding Cast Iron; Welding Practices for Cast Iron; Welding Large Gray Iron Castings; Bronze Welding of Cast Iron and Malleable Iron; Welding Brass and Bronze; Welding Monel Sheet and Castings; Welding Sheet Aluminum; Welding Cast Aluminum; High Carbon Steel and Alloy Steels; Welding Copper; Stelliting; Cutting Heavy Steel Sections and Heavy Cast Iron Sections; Precautions and Safe Practices, and Shop Layout and Organization.

There are twenty-five chapters, 205 pages and the book is fully illustrated. It is bound in paper and is sold at one dollar per copy. The book can be had by addressing the Company.

Electric Furnaces for Laboratories and Shops—The Automatic & Electric Furnaces, Ltd., London, England, has just issued a sixteen-page bulletin which describes an electric furnace, designed for general use in chemical and physical laboratories in connection with the heat treatment of materials. Copies of the bulletin can be had by addressing the above company.

American Newspaper Annual and Directory for 1927—W. W. Ayer & Son, Phialdelphia, Pa., have just published the American Newspaper Annual and Directory in two editions—regular edition at $15 and thin paper edition at $20.

It contains a carefully prepared list of newspapers and periodicals published in the United States, territories, and Dominion of Canada, Cuba and West Indian Islands, with valuable information regarding their circulation issue, date of establishment, political or other distinctive features, names of editors and publishers and street addresses in cities of 20,000 inhabitants and upward, together with the population of the counties and places in which the papers are published.

Rails and Fastenings—The Robert W. Hunt Company, Chicago, Ill., has just issued a booklet containing the specifications of the American Railway Engineering Association and the American Society for Testing Materials for open-hearth carbon steel rails, joints, spikes, and track bolts. The booklet can be had by addressing the Company at the above address.

Selling Transportation—An interesting little booklet on the subject "Selling Transportation," was recently published by Doyle, Kitchen & McCormick, Inc., a New York advertising agency specializing in transportation advertising.

Modern Central Stations—The Canadian Ingersoll-Rand Company, Limited, have for distribution to those interested two handbooks entitled, "Modern Central Stations." These handbooks consist of a collection of reprints of articles describing central stations, which articles have appeared from time to time in leading technical journals. The booklets are bound in loose-leaf form, convenient for filing, and provide an excellent ready reference of published data on modern fuel power stations. To date, the company has issued the first and second sections of this compilation, and it is their intention to reprint and make available for distribution future articles of the same nature. Copies may be secured from the Canadian Ingersoll-Rand Company, Limited, 260 St. James street, Montreal, Canada.

Railway and Locomotive Engineering

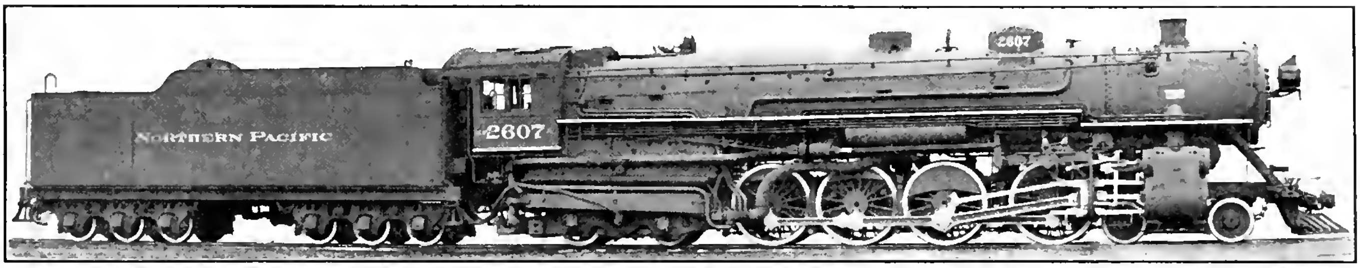
A Practical Journal of Motive Power, Rolling Stock and Appliances

Vol. XL 136 Liberty Street, New York, May, 1927 No. 5

4-8-4 Type Locomotive for the Northern Pacific

Designated the "Northern Pacific" Type — For Heavy Passenger Service — Tractive Force, 57,500 Pounds

The American Locomotive Company recently constructed twelve 4-8-4 type locomotives for heavy passenger service on the Northern Pacific Railway. The new design has been designated the "Northern Pacific" type, the first of which was delivered by the builders in December last. The locomotives were placed in service between Jamestown, N. D., and Glendive, Mont., and between Livingston, Mo., and Missoula, Mont. The latter division runs through mountainous territory where grades as high as 2.2 per cent are encountered.



New 4-8-4 Type Locomotive Built by the American Locomotive Company

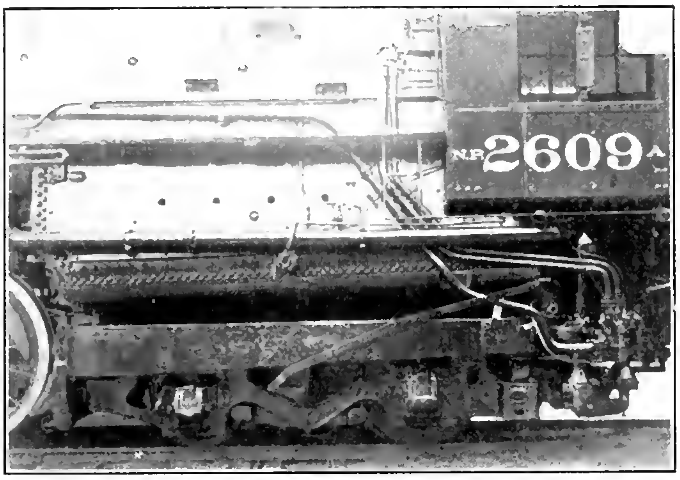
These locomotives develop a tractive force of 57,500 lb. without the booster, which provides an additional starting tractive force of 11,400 lb. The boiler carries a pressure of 210 lb. per sq. in. and the diameter and stroke of the cylinders is 28 in. by 30 in. The diameter of the driving wheels is 73 in. Trial runs made with these locomotives have shown that they are capable of hauling nine steel passenger cars up a 2.2 per cent grade without a helper and also of hauling unassisted 11 steel passenger cars over Bozeman Mountain on the Livingston-Missoula division, which has a grade of 1.8 per cent, at sufficient speed to maintain the schedule.

The design of the 4-8-4 type locomotive was the result of study on the part of the railroad company in co-operation with the builders to produce a locomotive of the best design and proportions to meet the operating conditions just described. The 2.2 per cent grade over which these locomotives operate was a factor in determining the tractive force of 57,500 lb., which with the addition of the trailer booster, is increased to 68,900 lb., which is a great advantage for starting or operation at slow speed over the maximum mountain grade. The weight carried on the drivers is 260,000 lb. which gives a factor of adhesion of 4.52. Although the pressure carried at the present time is 210 lb., the boilers and machinery are designed to carry a working pressure of 225 lb., so that if it is later desired to go to 225 lb. boiler pressure, in certain territory, the locomotive will develop a tractive force of 61,600 lb. exclusive of the booster, and a total tractive force of 73,975 lb. with the booster in operation.

The character of the sub-bituminous (Rosebud) coal used, which is of comparatively low B.t.u. content, had considerable influence in the design of the boiler and firebox. An exceptionally large grate area and firebox is required to satisfactorily burn this fuel. A total grate surface of 115 sq. ft. is provided, but it is the intention when burning a better grade of coal to reduce the grate area to about 95 sq. ft. To reduce the grate area, a temporary brick wall is installed on the grate bars in the front end of the firebox as shown in the elevation drawing. A steel plate cover is bolted to the grates underneath the temporary wall and is secured around the sides of the firebox in such a way as to prevent leakage of air. The installation is such, however, that the grates may be rocked when the wall is removed. The grates have been installed as nearly level as possible, which is considered the best practice when burning Rosebud coal. The firebox is built with a drop of only four inches in the mud ring from the back to the front end.

The long overhang at the rear and which resulted from the adoption of this large firebox, made it necessary to use a fourwheel trailer truck to carry the weight. Type B duPont-Simplex stokers are used, with the stoker engine located on the tender, which relieves the rear end of the locomotive of that item of weight. Q & C cast steel grate bars are applied instead of the customary cast iron. With the most careful designing, however, the weight on the trailer truck is 104,000 lb.

The boiler is of the wide firebox, conical-connection type, with a firebox 162 in. long by 102¼ in. wide. The combustion chamber is 74½ in. long. The total evaporative surface of the boiler is 4,600 sq. ft., which with the addition of the Type E superheater surface of 1,992 sq. ft., gives combined evaporative and superheating surface to 6,592 sq. ft. The smoke box is provided with a Mudge Security Unit spark arrestor and a single exhaust pipe with a nozzle 7 in. in diameter.



Trailer Truck and Firebox "Northern Pacific" Type Locomotive

The bracing used in the boilers of these locomotives is of the builder's standard design and consists of brace rods formed without welds and lugs made from flanged plate. The element of uncertainty relative to the strength of the welds is eliminated by the use of brace rods made of a single piece, instead of using jaws on each end of the rod which have been built up by welding. Lugs on the boiler shell made from flanged plate also avoid an element of uncertainty present in the case of drop forged lugs. Plate metal can be worked at a lower temperature without danger of burning.

Steam distribution is controlled by a Baker valve gear, designed for 87 per cent maximum cut-off and a Precision reverse gear. The cylinders are of cast steel and all steam cavities are designed to be self-draining. The stoker engine, dynamo, booster, blower and air compressor are operated with superheated steam.

The total weight of the engine is 426,000 lb. of which 260,000 lb. is carried on the drivers, 62,000 lb. on the front truck and 104,000 lb. on trailing truck. The total driving wheel base is 20 ft. 3 in. and the total wheel base of the engine is 47 ft. 2 in.

The engine truck is the constant resistance type having a Commonwealth cast steel frame cast in one piece. It has 36-in. diameter wheels with 7½-in. by 14-in. journals, provided with removable hub-liners. They are held in position against the face of the box by two projections, cast integral with the liner, which makes a dovetail fit in corresponding grooves in the face of the box. The two sections are held in place by a ¾-in. bolt, so located as to facilitate the removal of the liner. The engine truck axles are of forged steel, hollow bored.

All of these locomotives are equipped with Hubbard manganese steel crossheads. The frames are of high test vanadium cast steel. The front drivers are equipped with the Alco lateral motion device. The main driving boxes are fitted with supplemental bearings which extend below the horizontal center line of the journal to oppose the rapid wear below that line caused by the reciprocating piston thrusts. All of the driving wheel hubs, as well as the trailing truck hubs, are equipped with Smith adjustable hub liners made of Hunt-Spiller gun iron. The back end of main rods are equipped with floating bushings which work in Hunt-Spiller gun iron bushing pressed into the rod. All the crank pins, including the main, are hollow bored.

The four-wheel trailer truck is the Commonwealth Delta type having 36-in. wheels at the front and 45¾-in. wheels at the rear. The front axle is arranged to float laterally in the journal boxes as they do not assist in guiding the locomotive around curves. A Franklin booster, the exhaust of which is carried forward to the cylinder saddle, drives on the rear axle. A special design of the Commonwealth frame cradle was required in order to obtain the best possible ash pan capacity to meet the conditions imposed by the practically level mud ring of the firebox and by the four-wheel trailer truck. The rails of the cradle are located outside the wheels which gives it an overall width about equal to the outside width of the firebox.

TABLE OF DIMENSIONS, WEIGHTS AND PROPORTIONS OF THE "NORTHERN PACIFIC" (4-8-4) TYPE LOCOMOTIVE

Railroad	Northern Pacific
Builder	American Locomotive Co.
Type of locomotive	4-8-4
Service	Passenger
Cylinders, diameter and stroke	28 in. by 30 in.
Valve gear, type	Baker
Valve, piston type, size	14 in.
Maximum travel	9 in.
Outside lap	1 5/16 in.
Exhaust clearance	⅛ in.
Lead in full gear	5/16 in.
Cut-off in full gear, per cent	88.88
Weights in working order:	
On drivers	260,000 lb.
On front truck	62,000 lb.
On trailing truck	104,000 lb.
Total engine	426,000 lb.
Tender	313,900 lb.
Wheel bases:	
Driving	20 ft. 3 in.
Total engine	47 ft. 2 in.
Total engine and tender	90 ft. 0 in.
Wheels, diameter outside tires:	
Driving	73 in.
Front truck	36 in.
Trailing truck, front	36 in.
Trailing truck, rear	45¾ in.
Journals, diameter and length:	
Driving, main	12½ in. by 14 in.
Driving, others	11½ in. by 14 in.
Front truck	7½ in. by 14 in.
Trailing truck, front	7 in. by 14 in.
Trailing truck, rear	9 in. by 14 in.
Boiler:	
Type	Conical
Steam pressure	210 lb.
Fuel, kind	Sub-bituminous
Diameter, first ring, inside	82 7/16 in.
Firebox, length and width	162 in. by 102¼ in.
Combustion chamber, length	74½ in.
Tubes, number and diameter	33–3½ in.
Flues, number and diameter	182–3½ in.
Length over tube sheets	21 ft.
Grate area	115 sq. ft.
Heating surfaces:	
Firebox and comb. chamber	430 sq. ft.
Arch tubes	55 sq. ft.
Tubes and flues	4,115 sq. ft.
Total evaporative	4,600 sq. ft.
Superheating	1,992 sq. ft.
Comb. evaporative and superheating	6,592 sq. ft.
Tender:	
Water capacity	15,000 gal.
Fuel capacity	24 ton

The locomotive is equipped with American type multiple disc throttle valves built into the superheater header castings. This new design of throttle was described in the February, 1926, issue of RAILWAY AND LOCOMOTIVE ENGINEERING. Each of the locomotives is equipped with an Elesco exhaust steam injector; Ashcroft cut-off control gages; Weston speed indicator and Hoofer ratchet type flange oilers. Six of the locomotives are finished with Duco lacquer.

The tender, which has a capacity of 15,000 gal. of water and 24 tons of coal, is carried on two Commonwealth six-wheel trucks. The wheels are 37-in. in diameter and have 6½-in. by 12-in. journals. The tender frame is also a Commonwealth steel casting.

Advantages of the Roller Bearing and Locomotive Booster

Demonstrated in Operating Suburban Passenger Trains on the C. M. & St. P. Ry.

With the application of roller bearing equipment to complete trains in transcontinental service, operating 2,189 miles between terminals, the Chicago, Milwaukee & St. Paul Railway ranks as the leader of those roads that have experimented with or applied this improvement to rolling equipment. The results obtained in service on that road will be highly interesting.

In the November, 1926, issue of RAILWAY AND LOCOMOTIVE ENGINEERING there appeared an article describing the application of roller bearings to 127 standard passenger train cars on that road and in which was incorporated a graphic chart showing the relative values placed on the resistances, due to rolling friction of the standard A.R.A. and the roller bearing equipment, in starting from a state of rest and accelerating up to a speed of 60 miles per hour.

The application of anti-friction bearings together with experience from their use, both here and abroad, have been the subject of more recent articles in the pages of this publication. But, the interest of motive power and car equipment officers has been focused on the applications made on the C. M. & St. P. And as this road has recently completed a study of the economical advantages of roller bearings and the locomotive booster on a suburban train operating between Chicago and Elgin, Illinois, a distance of 36.6 miles with 16 stops, or with an average distance between stations of 2.28 miles. The following abstract from the results of that study or investigation, we are able to present through the courtesy of L. K. Sillcox, general superintendent of motive power of the railway.

Roller Bearing and Booster in Suburban Service

In the following data, charts, etc., it must be remembered that while a 12-car train with a gross weight of 480 tons was used as a basis for calculation, that the actual train operated had a less number of cars, and the resistances due to the rolling friction used were based on charts developed from tests as published in the October, 1926, issue of RAILWAY AND LOCOMOTIVE ENGINEERING. It should also be noted that the locomotive used was the class A4-s of the road which exerts a tractive force of 29,160 lbs. and a net pull at the drawbar of 27,960 lbs. This is ample for accelerating the train to the schedule speed required with plain A.R.A. bearings and without the aid of the booster. Therefore, the real advantages of the roller bearing and locomotive booster in quickly accelerating trains following station stops, a highly important factor in locomotive capacity and train movement, is not so pronounced or evident in the present display as their real merits deserve. With the foregoing suggestions for consideration in connection with the following data, we believe that the conclusions reached as to results and values may be considered as conservative in character.

Details of Trains and Running Time

(A) A 4-S—Plain Bearing Train 1 hr. 26 min. 47 sec.
(B) A 4-S—Booster-Plain Bearing Train 1 hr. 18 min.
(C) A 4-S—Roller Bearing Train 1 hr. 15 min. 18 sec.
(D) A 4-S—Booster-Roller Bearing Train 1 hr. 13 min. 17 sec.

Full details of the distances between stations in miles, the average grade and the running time between each station is given in the following tabulation:

SUMMARY OF RESULTS
CHICAGO TO ELGIN—36.6 MILES

Case A, A4S—Plain Bearing Train
Case C, A4S—Roller Bearing Train
Case B, A4S—Booster—Plain Bearing Train
Case D, A4S—Booster—Roller Bearing Train

Station	Distance Miles	Distance Miles	Average Grade	Running Time Between Stations—Seconds Case A	Case B	Case C	Case D
Union Station	..	..	....	....	....	....	....
Western Avenue	2.9	2.9	....	660.0	660.0	660.0	660.0
Hermosa	3.0	5.9	0.0 %	352.8	316.2	303.1	295.5
Cragin	1.1	7.0	+0.15%	212.4	179.6	170.3	161.1
Mont Clare	2.5	9.5	+0.2 %	340.7	297.6	288.2	279.0
River Grove	1.9	11.4	—0.25%	239.7	219.0	213.6	207.5
Franklin Park	1.8	13.2	+0.14%	288.8	239.6	229.2	220.7
Mannheim	0.8	14.0	+0.03%	186.7	144.0	137.5	131.9
Bensenville	3.2	17.2	+0.19%	392.3	348.6	334.0	324.4
Wooddale	1.9	19.1	+0.2 %	297.1	249.9	237.5	228.4
Itasca	1.9	21.0	—0.07%	261.4	226.9	221.8	213.7
Medinah	2.0	23.0	+0.4 %	312.8	274.0	262.5	251.5
Roselle	1.4	24.4	+0.49%	266.8	229.9	218.6	207.8
Ontarioville	4.0	28.4	+0.22%	452.2	408.5	384.6	375.3
Bartlett	1.7	30.1	—0.1 %	241.0	212.1	203.1	197.3
Spaulding	2.6	32.7	—0.24%	288.4	267.0	259.3	253.4
Elgin	3.9	36.6	—0.35%	414.3	407.3	394.3	389.3
Total				5207.4	4680.2	4517.9	4396.8

Expressed on a percentage basis, the results reflected in the tabulation and the saving in time is as follows:

	H. M. Sec.		Saving
(A) A4-S—Plain Bearing Train..........	1 26 47	100%	
(B) A4-S—Booster-Plain Bearing Train..	1 18 ..	90%	10%
(C) A4-S—Roller Bearing Train..........	1 15 18	87%	13%
(D) A4-S—Booster-Roller Bearing Train..	1 13 17	84.5%	15.5%

A greater saving in time would be reflected in other than suburban service where the distances between stations are short and where the train does not get the full benefit of the roller bearing and booster. This was particularly so in the present study as the locomotive used was of such ample capacity as to easily meet the schedule requirements without the improvements under consideration.

In accelerating a train from a state of rest to a speed of 45 miles per hour however, the advantages of the booster and roller bearings is more pronounced as shown from the results between Roselle and Ontarioville, a distance of 4 miles against a gradient of 0.22 per cent, which were as follows:

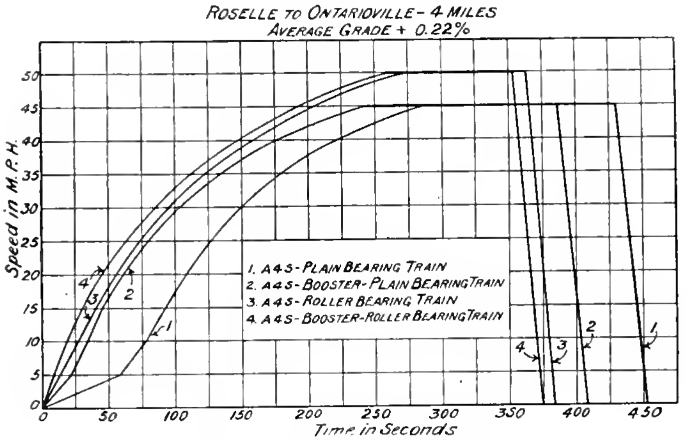


Fig. 1—Speed-Time Curves

(A) A4-S—Plain Bearing Train..............	286.9 sec.	100%
(B) A4-S—Booster-Plain Bearing Train......	243.2 sec.	85%
(C) A4-S—Roller Bearing Train..............	204.7 sec.	71%
(D) A4-S—Booster-Roller Bearing Train.....	194.4 sec.	68%

Here it will be noted that the saving in time from the booster and rolling bearing combined is 32 per cent. This approaches closely to the possibilities shown in the graphic chart that was published on page 36 of the February issue of this publication.

Speed-distance and speed-time curves are plotted for the section between Roselle and Ontarioville and are here reproduced as Figs. 1 and 2.

The locomotive used was the C. M. & St. P. class A4-S, Atlantic type, details of which are as follows:

Locomotive Data

Cylinders (2)	22×28 in.
Diameter of Drivers	79 in.
Boiler Pressure	200 lbs. per sq. in.
Weight on Drivers	121,540 lbs.
Weight on Trailing Truck....................	42,940 lbs.
Weight on Leading Truck.....................	44,320 lbs.
Weight of Tender	134,000 lbs.
Weight of Engine and Tender.................	342,800 lbs.
Rated Tractive Power	29,160 lbs.

The boiler capacity of the A4-S type locomotive is sufficient to take care of the additional steam consumed by the locomotive booster engines while the latter are in operation. The booster is cut out at 15 miles per hour.

The varying factors at different speeds up to 60 miles per hour are shown in the following table:

Speed in M. P. H.	Resistance Between Cylinders and Rim of Drivers—lbs.	Resistance of Engine and Tender Trucks—lbs.	Air Resistance—lbs.	Tractive Effort lbs.	Net Tractive Effort—lbs.	Tractive Effort Booster—lbs.	Drawbar Pull-Engine and Booster—lbs.
0	1,200	430	...	29,160	27,960	11,000	38,960
5	1,200	430	6	29,160	27,520	9,000	36,880
10	1,200	430	25	29,160	27,500	6,800	34,300
15	1,200	430	56	27,900	26,210	5,500	31,620
20	1,200	430	100	25,250	23,520	.....	23,520
25	1,200	430	156	22,600	20,810	.....	20,810
30	1,200	430	225	20,000	17,140	.....	18,140
35	1,200	430	306	17,800	15,860	.....	15,860
40	1,200	430	400	16,000	13,970	.....	13,970
45	1,200	430	505	14,350	12,210	.....	12,210
50	1,200	430	625	13,100	10,850	.....	10,850
55	1,200	430	756	11,950	9,540	.....	9,540
60	1,200	430	900	10,900	8,370	.....	8,370

As previously stated, the data used in connection with this study are based on the curves shown in the November, 1926, issue of RAILWAY AND LOCOMOTIVE ENGINEERING and which are again reproduced. These curves were originally read at the C. M. & St. P. annual Car Department Staff Meeting. The values of these curves are as follows:

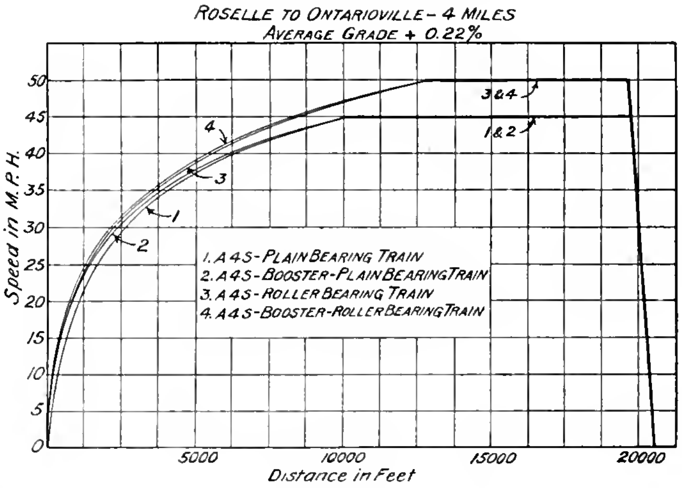


Fig. 2—Speed Distance Curves

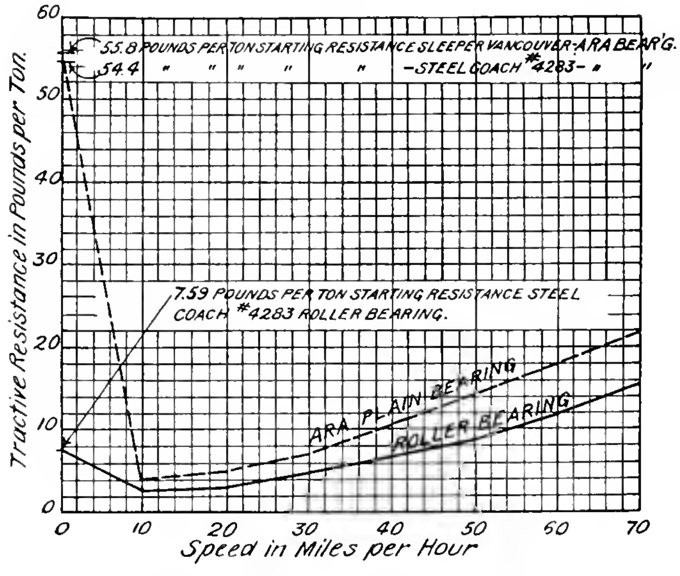


Fig. 3—Resistances of Plain and Roller Bearings

Speed M. P. H.	Resistance in lbs. per Ton Plain Bearing	Roller Bearing
0	54.0	7.5
1	50.0	7.0
2	46.0	6.5
3	40.0	6.1
4	34.0	5.8
5	29.0	4.5
10	4.0	3.0
15	4.8	3.0
20	5.4	3.3
30	7.0	5.0
35	9.0	6.0
40	10.5	7.0
45	12.3	7.8
50	14.3	9.0
55	16.0	10.0
60	18.0	12.0

It must be borne in mind that the figures are obtained for cars of 75 ton weight, while the cars in suburban service have an average weight of about 40 tons. However, it is a well known fact that the resistance in pounds per ton of a heavier car is less than that of a lighter car. No attempt was made in this study to modify the resistance value to suit 40 ton cars, for the reason that the resistances are already seemingly high and deemed applicable to 40 ton cars.

Detail Calculations

Calculations to determine the force available to overcome grade resistance and also for acceleration in pounds per ton weight of engine and train.

a. *A4S—Plain Bearing Train.*

Weight of engine and tender .... 171.4 tons
Weight of 12 cars @ 40 tons .... 480 tons

Speed M.P.H.	Drawbar Pull-Lbs.	Train Resistance Lbs./ton	Train Resistance Lbs.	Force available to overcome grade resistance and acceleration Lbs.	Lbs./ton	Average
0	27960	54.0	25920	2040	3.14	....
1	27880	50.0	24600	3880	5.97	4.56
2	27800	46.0	22080	5720	8.8	7.39
3	27710	40.0	19200	8510	13.08	10.94
4	27620	34.0	16320	11300	17.36	15.22
5	27520	29.0	13160	14360	22.1	19.73
10	27500	4.0	1920	25580	39.3	30.7
15	26210	4.8	2300	23910	26.72	38.01
20	23520	5.4	2590	20930	32.2	34.46
25	20810	6.0	2880	17930	27.6	29.9
30	18140	7.0	3360	14780	22.72	25.16
35	15860	9.0	4320	11540	17.75	20.24
40	13970	10.5	5040	8930	13.72	15.73
45	12210	12.3	5910	6300	9.68	11.75
50	10850	14.3	6970	3880	5.97	7.82
55	9540	16.0	7680	1860	2.86	4.42
60	8370	18.0	8640	—270	—.42	1.22

b. *A4S—Booster—Plain Bearing Train.*

Weight of engine and tender and booster ...... 175 tons.
Weight of 12 cars @ 40 tons .... 480 tons.

Speed M.P.H.	Drawbar Pull-Lbs.	Train Resistance Lbs./ton	Train Resistance Lbs.	Force available to overcome grade resistance and acceleration Lbs.	Lbs./ton	Average
0	38960	54.0	25920	13040	19.9	....
1	38600	50.0	24000	14600	22.3	21.1
2	38150	46.0	22080	16070	24.56	22.43
3	37750	40.0	19200	18550	28.36	26.46
4	37300	34.0	16320	20980	32.1	30.23
5	36880	29:0	13160	23720	36.24	34.17
10	34300	4.0	1920	32380	49.5	42.87
15	31620	4.8	2300	29320	44.8	47.15
15	26210	4.8	2300	23910	36.54	34.27
20	23520	5.4	2590	20930	32.0	....
25	20810	6.0	2880	17930	27.4	29.7
30	18140	7.0	3360	14780	22.6	25.0
35	15860	9.0	4320	11540	17.65	20.13
40	13970	10.5	5040	8930	13.65	15.65
55	9540	16.0	7680	1860	2.84	4.39
60	8370	18.0	8640	—270	—.41	1.22
45	12210	12.3	5910	6300	9.63	11.64
50	10850	14.3	6970	3880	5.93	7.78

c. *A4S—Roller Bearing Train.*

Weight of engine and tender .... 171.4 tons
Weight of 12 cars @ 40 tons .... 480 tons

Speed M.P.H.	Drawbar Pull-Lbs.	Train Resistance Lbs./ton	Train Resistance Lbs.	Force available to overcome grade resistance and acceleration Lbs.	Lbs./ton	Average
0	27960	7.5	3600	24360	37.4	....
1	27880	7.0	3360	24520	37.7	37.55
2	27800	6.5	3120	24680	37.9	37.8
3	27710	6.1	2930	24780	38.0	37.95
4	27620	5.8	2790	24830	38.2	38.1
5	27520	4.5	2160	25360	38.9	38.55
10	27500	3.0	1440	26060	40.0	39.45
15	26210	3.0	1440	24750	38.0	39.0
20	23520	3.3	1580	21940	33.7	35.85
25	20810	4.0	1920	18890	29.0	31.35
30	18140	5.0	2400	15740	24.2	26.6
35	15860	6.0	2880	12980	19.9	22.05
40	13970	7.0	3360	10610	16.3	18.1
45	12210	7.8	3750	8460	13.0	14.65
50	10850	9.0	4320	6530	10.0	11.5
55	9540	10.0	4800	4740	7.2	8.6
60	8370	12.0	5760	2610	4.0	5.6

d. *A4S—Booster—Roller Bearing Train.*

Weight of engine and tender and boster .... 175 tons.
Weight of 12 cars @ 40 tons .... 480 tons.

Speed M.P.H.	Drawbar Pull-Lbs.	Train Resistance Lbs./ton	Train Resistance Lbs	Force available to overcome grade resistance and acceleration Lbs.	Lbs. ton	Average
0	38960	7.5	3600	35360	54.0	....
1	38600	7.0	3360	35240	53.8	53.9
2	38150	6.5	3120	35030	53.6	53.7
3	37750	6.1	2930	34820	53.2	53.4
4	37300	5.8	2790	34510	52.7	52.95
5	36880	4.5	2160	34720	53.0	52.85
10	34300	3.0	1440	33860	51.7	52.25
15	31620	3.0	1440	30180	46.2	48.95
15	26210	3.0	1440	24770	37.8	....
20	23520	3.3	1580	21920	33.5	35.65
25	20810	4.0	1920	18890	28.84	31.17
30	18140	5.0	2400	15740	24.08	26.46
35	15860	6.0	2880	12980	19.85	21.97
40	13970	7.0	3360	10610	16.2	18.03
45	12210	7.8	3750	8460	12.93	14.55
50	10850	9.0	4320	6530	9.78	11.36
55	7540	10.0	4800	4740	7.25	8.51
50	8370	12.0	5760	2610	4.0	5.6

For the information and convenience of those who may wish to check items of special interest, the following formula used in connection with the study of the C. M. & St. P. are reproduced.

Let T=Net tractive effort in pounds per ton of train and engine.
R_T=Train resistance in pounds per ton of train.
R_G=Grade resistance in pounds per ton of train and engine.

Considering the train is accelerated from a low speed V_1 to a higher speed V_2, then

A=Net accelerating force available=$T-(R_T+R_G)$

The relation between the accelerating force, A; initial and final velocities, V_1 and V_2; and the distance travelled in changing from V_1 to V_2, L, is expressed thus—

$$A=70\,\frac{(V_2^2-V_1^2)}{L} \quad \text{..........} \quad (1)$$

$A=T-(R_T+R_G)$ in pounds per ton.
V_1 and V_2 in miles per hour.
L distance in feet.

The values of T and R_T vary with the speed. However, if the speed increment is taken to be small, the average values of T and R_T may be expressed, thus—

$$T=\frac{T(v_2)+T(v_1)}{2} \quad \text{..........} \quad (2)$$

$$R_T=\frac{R_T(v_2)+R_T(v_1)}{2} \quad \text{..........} \quad (3)$$

From equation (1), we obtain

$$L=\frac{70(V_2^2-V_1^2)}{A} \quad \text{..........} \quad (4)$$

and t, time required to cover distance L, in seconds

$$t=\frac{L}{\dfrac{1.466(V_2+V_1)}{2}}=\frac{1.364.L}{V_1+V_2} \quad \text{..........} \quad (5)$$

Equations (4) and (5) are valid only when V_1 and V_2 are taken close together.

Solving equations (4) and (5).

$$t=\frac{95.5(V_2-V_1)}{A},\quad L=.733(V_1+V_2)\,t$$

Resistance of Locomotive and Tender (Grade Resistance Net included) $=A+B+C$, in which

A=Resistance between cylinder and the rim of drivers in pounds $=18.7\ T+80N$

T=Tons, weight on drivers and

N=Number of driving axles

B=Resistance of engine and tender trucks in pounds $=2.6\ T+20N$, in which

T=Tons, weight on engine and tender trucks and

N=Number of Truck Axles

C=Head and "Air" resistance in pounds $=.002V^2\times A$, in which

V=Velocity in miles per hour, and

A=End area of Locomotive, taken as 125 sq. ft.

$C=0.25\ V^2$. The number of pounds of air resistance for various velocity is given below.

AIR RESISTANCE OR "C"

Miles Per Hour	Resistance in Pounds
5	6.25
10	25.0
15	56.0
20	100.0
25	156.0
30	225.0
35	306.0
40	400.0
45	505.0
50	625.0
55	756.0
60	900.0

Resistance between cylinder and the rim of drivers

$R_1=18.7T+80N$

$T=60.77 \qquad N=2$

$R_1=1036+160=1200$ pounds

Resistance of engines and tender trucks

$=2.6T+20N$

$T=110.63 \qquad N=7$

$=228+140=430$ pounds

In the matter of air resistance, it will be noted that the area of the front end of the locomotive is taken as 125 square feet and the resistance to be overcome graduates from 6.25 lbs. at 5 miles per hour to 900 lbs. at 60 miles per hour, which calculation is in accordance with general accepted practice. It is a well known fact however, that the impinging or retarding effect of the air on coaches throughout the train, particularly when coming from an angle, also the vacuum or suction effect on the rear of the train is a factor to reckon with, but has not been included in this study or trial test.

The foregoing results obtained from a comparative study of trains equipped with roller bearings and locomotive booster and trains not equipped with these devices as made by Mr. Sillcox constitutes a valuable addition to railway engineering literature, and will no doubt result in renewed activity on the part of all those interested in this most important subject.

What Is the Real Cost of Locomotive Fuel*

By L. K. SILLCOX, General Supt. Motive Power Chicago, Milwaukee & St. Paul Ry.

The various sections of the American Railway Association have been actively co-operating and intensely studying the problems of fuel conservation. An endeavor has been made, insofar as possible, to accurately picture the amount of fuel which may be really essential in order to properly move a net amount of revenue business. It is a subject that cannot be touched upon without compassing the activities of the entire railroad family, nor can the solution be found except through constructive educational contacts. Clear analysis of what present performance is and what intended objectives are need to be carefully presented. If this is not done, a general desire to conserve will not have been built up on the part of those directly concerned. Conviction needs to be gained on the part of each person in the service that the problem of conserving fuel is vital and a first responsibility upon management is an endeavor to truly attain proper and economical operation. Whatever measures are taken to accomplish the end which is sought always will result, when thoroughly planned, in affecting every branch of the service and consequently there is an immediate need for united endeavor in the co-ordinated spirit of right performance.

In explanation of some of the practical considerations to be met, it may be stated that all fuel used by locomotives, whether in train service, yard service, being fired up in the roundhouse or awaiting call, is charged as locomotive fuel so that any comparison of performance of the quantity employed and the resultant cost depends among other things, upon the handling of locomotives, the frequency of cooling down and firing up, and many other features. To the cost of locomotive fuel is also charged the cost of freight over foreign lines and the cost of running through coal chutes and other fuel handling facilities. The cost of hauling company fuel over company lines is not allocated to the cost of fuel, but is charged against transportation expense as well as maintenance of way and maintenance of equipment expense.

Fuel of various kinds is equated to the coal tonnage basis. Equation factors, which are more or less unfortunately optional with individual carriers, are used for oil and electricity. Wood and other material used for firing up locomotives at terminals are also equated to fuel tonnage in terms of coal. Statistics as to the consumption of fuel are confined to ward and train service, although some data is available for work train service. A small percentage of the fuel employed is consumed in shops and power plants. The fuel used in the latter case is not charged out as such, but goes into the power plant shop expense for distribution. Train yard power produced and purchased is charged to Operating Expenses to represent the amounts paid for current purchased or produced for general use; however, kilowatt hours consumed in yard and train service are reported as fuel tonnage consumed by means of equation factors.

The fuel performance of Class I carriers for the year 1926 is not yet available in detail, except for train and yard performance, so that, for the purpose of determining the real cost of fuel, it is necessary to go back to the year 1925 to permit of a more detailed analysis. The following statement shows the total number of equated tons of fuel reported consumed by Class I carriers in 1925 and the charges under the various accounts made therefor:

No. I

Fuel Consumption & Cost—1925

Service	Tons Consumed	Charges Made	Cost Per Ton
Freight	79,367,898	....	.....
Passenger	29,328,275	....	.....
Mixed	1,840,343	....	.....
Special	58,272	....	.....
Total Train	110,594,788	....	.....

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*Address before the Convention of the International Railway Fuel Ass'n.

Train Fuel Charges.......	.....	$340,502,586	.....
Train Power Produced and Purchased.........	....	8,169,861	.....
Total Train Fuel Cost.....	....	$348,672,447	$3.1527
Yard Fuel..................	22,174,755	$ 66,760,458	.....
Yard Power Produced and Purchased.........	.. ..	474,041	.....
Total Yard Fuel	....	$67,234,499	3.0320
Total Train and Yard....	132,769,543	415,906,946	3.1330
Work Train Service.......	2,641,618	Distributed to other accounts	.....
Total Tons Consumed By Locomotives........	135,411,161	....	.....

The cost of $3.13 per ton of fuel consumed in train and yard locomotives includes the purchase price, the purchasing expense, the cost of inspection, the cost of any losses while being transported from mines to point of use, the losses in deterioration in quality or quantity due to time elapsing from the mines to actual use in transportation service, the cost of labor and material operating fuel handling plants, the cost of storing and the cost of accounting for the amounts used. This cost represents the fuel into the tender. It does not include the cost of maintaining scales, fuel handling facilities, power distribution lines, operating charges in connection with rolling stock needed, enginehouse expense involved, the cost of hauling freight over foreign lines and the consequent administrative features. If the real cost of fuel is to be determined it has to be traced into the firebox for the major elements involved.

The quantity of equated fuel used and the cost per locomotive mile was as follows in 1925:

No. II

Service	Pounds of Equated Fuel Per Locomotive Mile	Cost of Fuel Per Locomotive Mile c.
Freight	220.0	34.67
Passenger	101.6	16.01
Mixed	140.0	22.07
Special	161.6	25.47
Total Train	167.0	26.32
Yard	136.7	20.73
Total Train & Yard	161.1	25.24

This represent the quantity and cost of fuel per locomotive mile in transportation service, this cost being based on the charges into the tender, but excluding other elements and cost involved as already explained.

In order to ascertain the cost of fuel into the firebox other elements are to be considered because they are incurred in connection with handling fuel. The cost of maintaining fuel handling facilities amounted to the following in 1925:

No. III

Fuel Station	$4,432,807
Substation buildings	52,394
Substation apparatus	277,911
Power transmission lines.............	312,447
Power distribution lines..............	2,666,975
Power line poles and fixtures..........	489,575
	$8,232,109

These facilities are used for power purposes, not only for operating trains, but for general purposes so that the total amount is not applicable to the cost of handling fuel used in transportation service. Since this expense is not segregated in the accounts it cannot be stated just what portion is applicable to fuel used in transportation locomotives, but if we consider that 2 per cent of the total charge for fuel is for train and yard power produced and purchased, then 2 per cent of the maintenance cost of the facilities, excluding fuel stations, could be added or approximately $75,980 for this purpose, making the total amount incurred $4,508,787. This would add approximately 3.4c. per ton to the cost of fuel as charged originally. It is not possible to state from the record just what the actual cost is for handling locomotive fuel at coaling stations, however, an average expense of 7.0c. per hour direct labor chargeable to this is a conservative amount and would in such a case represent an outlay of $9,478,781, which is included in cost of $3.132, per ton.

The handling and hauling of fuel requires a considerable portion of the transportation plant. Cars are needed to haul company fuel. When deducting power produced and purchased from the equated tonnage of fuel consumed in transportation service the balance may be considered as fuel which must be hauled in cars. Approximately 130 million tons of equated fuel were hauled. In order to arrive at the cost of transporting fuel, it is necessary to calculate the net ton miles involved and this requires an estimate of the average length of haul. The average length of haul per ton of all commodities transported in 1925 was 179.38 miles. If we assume that fuel required an average haul per ton of 150 miles, this would appear to be conservative, therefore, this would amount to 150 miles times 130 million tons of fuel or 19,500 million net ton miles of fuel or approximately 54 per cent of the total non-revenue ton miles handled by Class I carriers in 1925. Considering that the average tonnage carried per loaded car was 45 and that freight cars moved approximately 11,500 miles per year each, of which 70 per cent was loaded car miles, this would indicate approximately 8,000 loaded car miles or 360,000 net ton miles hauled per car. This divided into the total of 19,500 million net ton miles of fuel handled would represent a need of 4,166 fuel handling cars. In 1925 the average cost of maintaining all classes of freight cars was $158 for the year. Open top cars cost somewhat less to maintain than house cars, so that if we estimate the open top cars and include a small portion of tank cars at an average of $100 per car per year, this would represent a cost of $5,416,600. The average charge to Operating Expenses for depreciation per car was $46 and for retirements $9 and as the fuel handling cars do not represent the average value of freight train cars, this may be reduced from $55 to approximately $30 per year for depreciation and retirement, or a total of $1,684,980. The total operating charges in connection with maintaining such cars would, therefore, be approximately $7,101,580. This would add 5.3c. per ton to the cost of fuel. The cost of maintaining and owning the freight cars required to haul fuel, if calculated on the per diem basis, would be much more than this estimate shows but is not used here because of a desire to be entirely conservative.

The motive power required to haul fuel is calculated on the basis of using the average net tons per train in 1925 or 744, because practically all fuel is hauled in revenue trains in connection with other commodities. The average miles per day per locomotive owned, which takes into consideration the locomotives out of service for repairs, those stored, etc., amounted to 58.2, so that the resultant net ton miles per locomotive day, considering one train handled per day, would indicate 43,300. Since the average miles of 58.2 represents locomotives out of service for repairs, storage, etc., no further reduction in service days of the year need be made and 365 days times 43,300 net ton miles hauled per locomotive day would be 15,804,500 net ton miles of fuel hauled per locomotive year, and this divided into the total net ton miles of fuel hauled throughout the year as previously stated would represent 1,234 locomotives used for this purpose. This refers to road or train locomotives. In addition yard locomotives were used for switching fuel cars for trains and at fuel stations so that approximately 10 per cent may be added to the estimated number of locomotives required to haul fuel, making a total of approximately 1,357 units. The average cost of repairs, depreciation and retirements per locomotive owned in 1925 as indicated by the charges was as follows:

Repairs	$7,246
Depreciation	820
Retirements	80
Total	$8,146

The 1,357 locomotives, therefore, incurred a total charge of $11,051,322. This would add 8.3c. to the cost per ton of fuel.

The locomotives used in this service incur a charge to Enginehouse Expense for turning. In 1925 the total charge for turning yard and train locomotives was $113,666,990. The 1,357 locomotives used in yard and train service incurred a portion of this charge. The 1,234 train locomotives, in other words, incurred a portion of the charge of $83,147,164 for train Enginehouse Expense and the 123 additional yard locomotives incurred a portion of the charge of $30,524,826 for yard Enginehouse Expense. The total of 1,357 locomotives in train and yard service represent approximately 2 per cent of the total locomotives owned by Class I carriers, so that this per cent of the total charge to Enginehouse Expense would amount to $2,275,000 or 1.7c. to be added to the cost of fuel. This is based on total locomotives owned, and when reduced to the percent of active locomotives, the result is changed but slightly and not enough to affect the final cost materially. In other words, 2 percent was used as representing the power involved, whereas this would be approximately 2.4 percent of the total Enginehouse Expense and the use of 2 percent represents a more conservative estimate for that reason.

The cost of firing locomotives in yards and trains or conveying fuel from the tender to the firebox is estimated by taking approximately 40 per cent of the total cost of yard or train enginemen, exclusive of yard and train motormen. The total charge for this expense was $313,834,854, of which 40 per cent represents $125,534,000, or adding approximately 94.5c. to the cost per ton of fuel into the firebox.

The items which have been estimated individually thus far do not represent the total expense, since there must be added the cost of train crew expense, dispatching, maintenance of roadway facilities, general administration and other expenses which it is difficult to set up specifically by individual accounts. For that reason further calculation is made to cover these items in the following way: The 132,769,543 tons of fuel reported as used in transportation service were calculated as having had an average haul of 150 miles, which gave approximately 19,500,000,000 net ton miles involved. The revenues per ton mile of freight in 1925 amounted to 1.097c., which when reduced by the operating ratio of 74.1 gave the operating cost per net ton mile or .8129c. This may appear somewhat high because the revenue rate on fuel is below the average, but since fuel is handled in revenue trains the average is taken for this purpose and the result is $158,515,500 as the total cost in addition to the original charge for fuel. This amount added to the cost of fuel or $415,906,944 would give a total of $574,422,444, or $8,041,811 in excess of the individual items calculated and would represent the expense not calculated to arrive at the total. This amount would add approximately 6c. to the cost of fuel per ton.

The items referred to thus far when summarized indicate the following amounts:

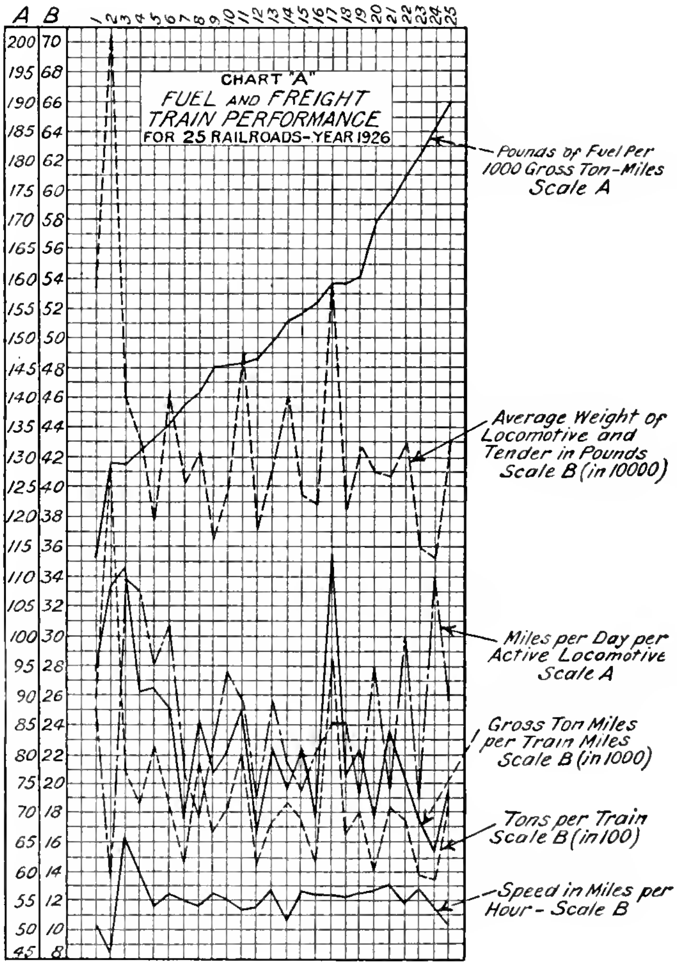
No. IV

	Cost of Fuel	Cost Per Ton
Cost of fuel	$415,906,944	$3.132*
Maintenance of fuel handling facilities	4,508,787	.034
Freight car repairs, depr'n and retirements	7,101,580	.053
Locomotive repairs, depr'n and retirements	11,054,122	.083
Enginehouse expense	2,275,000	.017
Firing locomotives in service	125,534,000	.945
	566,380,435	4.265
Other operating expenses	8,041,811	.060
	574,422,445	4.325

*Includes handling cost at Fuel Stations of 7.0c per ton.

This has resulted in adding 38.3 per cent to the original unit charge-out price of fuel and it is important to observe that this addition does not fluctuate with price ranges in fuel but is a definite charge on a tonnage basis and the percentages shown will of course vary with the price unit for fuel but will not change much in sum total.

There has been improvement in the past few years in the fuel performance of locomotives and at the same time there has been a tendency to use fuel of lower quality.

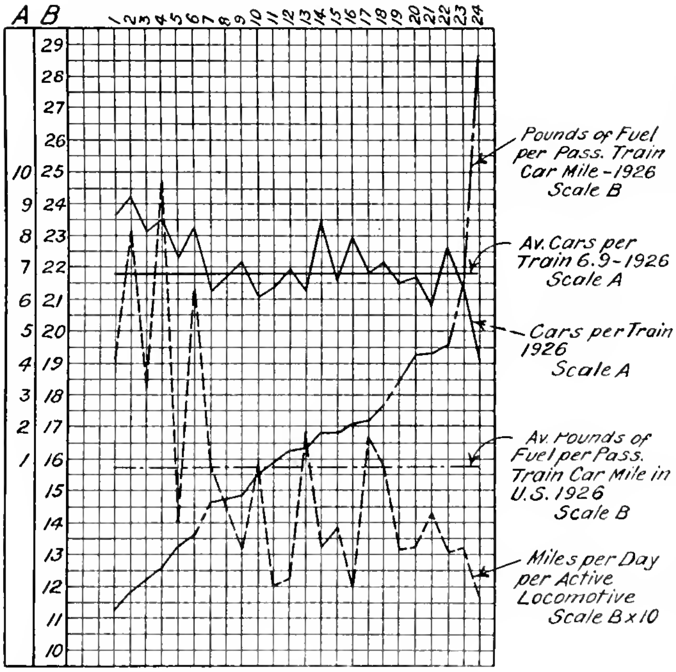


The thermal value of fuel, that is coal and oil, used throughout the country, varies from 8,000 to 18,000 B.T.U. or a range of 125 per cent from the minimum to the maximum. There is no specific data at hand to show the average thermal value of fuel used by individual Class I carriers. If the base price of fuel were to fluctuate in direct proportion with the thermal value, then the cost of fuel would be the same if the relative utilization of thermal units were the same, but the performance in pounds of fuel per thousand gross ton miles would be affected accordingly, to some degree. Whether a high or low quality of fuel is used in addition to the base price, so far as handling costs are concerned, will be about the same except where improvements in fuel handling facilities are made. The cost of handling fuel through the facilities required, particularly those of modern design, will average about 5c. per ton as compared with the poorer facilities where the cost will range from 20c. to 25c. per ton and the importance of the character of facilities provided, together with the proper location for transportation service, cannot be over-stressed. In like manner the provision by carriers of self-cleaning coal cars where required is another feature leading to the conservation of resources, prompt handling of cars and reduction in the handling expense.

Locomotives have been improved in design and the development of appliances for reducing the fuel consumption has steadily progressed. The increase in efficiency of performance of motive power has more than offset any decrease in thermal quality of fuel used. A brief study of 25 of the larger Class I carriers indicate the operating features affecting fuel performance. Chart A has been drawn for the purpose and shows the pounds of fuel per thousand gross ton miles hauled in freight service in relation to the average weight of freight locomotives owned to express the average size, the average train speed from initial to final terminal, the average tonnage per train and the resultant gross ton miles per train hour. Freight train speed has an important bearing on fuel performance in some cases in that it expresses the degree of road movement interruption and it is evident that the consumption of fuel in road service can be reduced with improved facilities for uninterrupted train movement, by the elimination of unnecessary or avoidable stops for crossings, heating trains, fuel, water, etc. The increase in the size of tenders and relocation of fuel and water stations has brought about a reduction in the number of stops for fuel and water. The gross tons per train indicate that they follow closely the average size of power and the gross ton miles per train hour has improved on those lines where improved speed or movement conditions are present in relation to the tons per train. The average miles per day per locomotive as calculated from the records is affected somewhat by the method of reporting locomotives stored and unserviceable, but indicates that this is entirely a question of management and local conditions.

PASSENGER SERVICE 1926

POUNDS OF FUEL PER PASSENGER TRAIN CAR MILE, CARS PER TRAIN, AND MILES PER DAY PER ACTIVE LOCOMOTIVE.



In general, the pounds of fuel per thousand gross ton miles increased somewhat with the decrease in size of power with a few exceptions and this is similarly affected in the resultant performance as to gross ton miles per train hour. It is interesting to note from this chart that carrier number one, for instance, has a normal train speed, a fairly average locomotive mileage per day, a rather high tonnage per train and a good performance as to gross ton miles per train hour, resulting in a low consumption of fuel per thousand gross ton miles. This is in contrast with carrier number two, having very large power and heavy train tonnage with a good performance in gross ton miles per train hour, but with a slow train speed, resulting in the fuel consumption being greater than carrier number one. The effect of train speed is rather marked in this case as regards fuel consumption. Carrier number three shows a high train speed but a lower train tonnage than carriers number one and two, with the effect that the fuel consumption is about the same as that of carrier number two, the latter having a low train speed.

The carriers having the best performance in pounds of fuel per thousand gross ton miles have a high grade of fuel. It is apparent from the chart and from what knowledge can be gained of the fuel quality that the quality is not so important a factor as train performance because carrier number twenty-five has a better grade of fuel than many of the carriers having less consumption per thousand gross ton miles. It is well to mention the fact that the physical characteristics of a railroad have a bearing on the fuel performance; in other words, the N. Y. C. because of its favorable grade line should make a better showing than either the P. R. R. or B. & O.

One cannot refrain from suggesting that a study of the facts emphasizes the need for intensive study and application of design in relation to type of grates, size of firebox as regards rate combustion and the ratio of heating surface to grate area as well as cylinder and valve motion efficiency. The modern locomotive of proper design should perform with less fuel in relation to work done than the older types.

Chart B shows the pounds of fuel per passenger train car mile in relation to the number of cars per train and the average miles per day per active passenger locomotive. This indicates that the performance improves with the increase in size of trains and consequent increase in average size of power. No specific information is available, however, to show the average size of power owned by these carriers. Apparently the relative fuel consumption decreases in this case with the increase in size of power and trains somewhat the same as in freight performance, provided available tractive effort is utilized to the fullest extent. No factor is available to indicate the effect of train speed on fuel consumption in passenger service. This chart also indicates the importance of high utilization of passenger power, since the curve showing the miles per day per active locomotive reflects a trend in mileage performance which varies inversely with the fuel consumption.

In general, as locomotive utilization is increased, particularly by long runs, the frequency of turning or terminal attention is reduced in relation to the mileage run. It has been estimated that the loss of fuel incurred in the usual terminal handling of locomotives at roundhouses because of cooling down and firing up is from one-half to one ton of fuel per locomotive turned, so that any reduction in the frequency of turning power should result in further fuel economy.

The heat from the pounds of fuel burned in the firebox of a modern steam locomotive produces one-twelfth or 8 per cent of the total useful work at the tender drawbar, while a modern stationary steam generating plant can utilize many times that per cent of the thermal value of fuel. It is appreciated that it is not possible to design locomotives with the fuel efficiency of stationary steam generating plants. The cost of fuel per ton into the locomotive firebox has been stated as $4.33 for the year 1925.

With only 8 per cent of the heat utilized due to stack, back pressure and other losses it would indicate that for Class 1 carriers the cost per ton of fuel so far as results are concerned was the amount of which $4.33 is 8 per cent or $54.13. If the matter is viewed in this light, it is apparent that much remains to be done to increase the use of the heat available. For instance, in locomotives having 10 per cent available energy from fuel at the drawbar the cost per ton would be $43.30 as compared with $54.13 where only 8 per cent is available.

When we consider the conducting of transportation with greatest efficiency and least cost we need to keep in mind two things which militate against this attainment in general practice. One is the fact that the schedule for time and tonnage loading is determined by the transportation department very often without going into the matter thoroughly with the motive power department. As a rule, the transportation officials have not the information or data necessary to determine the load and speed combinations needed to give the least cost and greatest efficiency. The other is that some operating officers consider high train tonnage only as an ideal induced by being commended for hauling the greatest number of tons per train, whereas those officers operating with less tonnage per train may not receive the same consideration even though the net cost to the railway may have been more favorable.

The important factor underlying the proper fixing of tonnage to be hauled by locomotives and which has a primary influence on the question of fuel consumption is the time which may be used in hauling a train over a controlling section of road. The operating and motive power departments should take interest to see that tonnage is properly applied to locomotives for movement over the line.

Traffic considerations are based upon the character of business handled, one extreme being where business is handled as dead freight for which quick dispatch is not essential, the other where the character of traffic is such as to require rapid movement. Each division of the system needs individual analysis with respect to—

1—Character of motive power.

2—Physical character of the division, such as grades, alignment, etc.

3—Whether the division is single or double track with available passing tracks and terminal facilities.

4—Density of traffic.

The analysis for one division may or may not apply to other divisions and in general it will not. One of the most certain requirements is to have such motive power facilities as will insure prompt handling of locomotives at terminals with a view to increasing the available service hours for transportation purposes.

Smoke undoubtedly attracts more attention to waste in the firebox than any other visible means, except it be safety valves blowing unnecessarily, which represent indirect as well as compounded fuel losses.

Much can be done in the matter of supplying uniform qualities and preparation of coal for the different divisions by providing one kind of coal on an engine district. This enables locomotives to be properly drafted, have suitable grates provided and permit of road men being acquainted with the method of procedure as to the best means of conserving fuel. The suitable quality of fuel properly prepared for use is a primary necessity.

The question of running steam locomotives in order to obtain the most economical results involves the work of both the engineer and fireman and if they do not function as they should, no amount of excellence in engineering, design, construction, or maintenance practice will matter much. The feature of firing fuel and feeding water to a boiler has much to do with steaming qualities. To obtain best results these two operations must be performed in harmony with each other. An engineer should be taught not to work the locomotive harder than necessary, consistent with the train to be handled and time to be made.

Nothing is so disheartening to the men on the line than to be judged on the basis of improperly prepared statistics which fail to reflect actual conditions. A desire to conserve fuel, and in fact everything else on the railroad, must be built up on a foundation of genuine regard for mutual best endeavor and comparisons need to be made on the basis of full and fair accounting with a consideration of real regard for the true conditions existing.

The New York Interborough Subway System

With Some Details of Its Efficient Shop System

By J. B. NEALEY

In addition to being the world's most extensive subway system the Interborough Rapid Transit Company serving New York City and environs is probably one of the fastest and most efficiently operated railroads in existence, steam or electric, and it is only 23 years old. This system has 385.81 miles of single track of which 247.22 miles are subway and 138.63 elevated lines. Approximately 4,000 cars are operated on the various lines and on an average week day 2,750,000 people are transported in the subway and 1,000,000 on the elevated. Very nearly three million persons have been carried in the subway in a single day. In order to maintain such service, the average headway of subway express trains, during the rush hours, that is, the time interval of trains entering stations, is only one minute and 48 seconds. Some 15,000 employees are required to man the system.

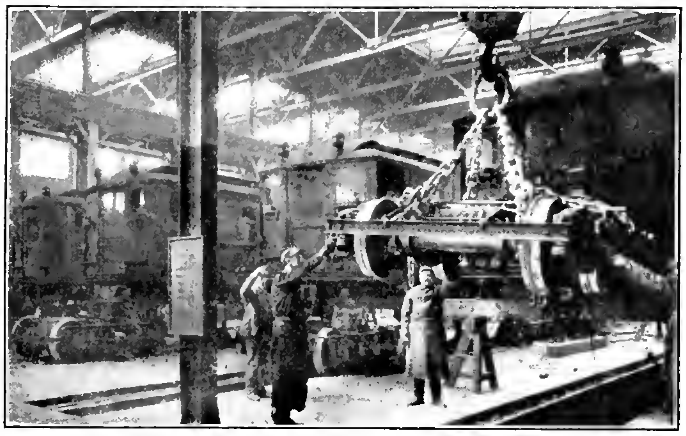
The safest railroad in the world is another distinction to which the Interborough Rapid Transit lays claim by keeping its accident rate lower than that of any other road, despite the fact that for the fiscal year ending June 30, 1926, it carried 1,130,484,647 persons of which 784,280,075 rode in the subway and the balance on the elevated. The company has six pairs of tunnels, twin tunnels, three running under the East River and three under the Harlem River. The system affords the longest ride for a nickel of any road in America or some 27 miles, and for this sum one can ride from a point in Brooklyn to the upper Bronx, near the city line.

The lowest point on the lines is at a place in the Queensboro tube which is 104.33 feet below mean high water in the East River while the highest point is on the elevated at 110th stret and Eighth avenue, which is on a level with the roofs of the five story buildings.

The two points of heaviest congestion in the world are Times Square and Grand Central Station, New York City, both places being served by the Interborough Rapid Transit subway lines. In the rush hours it requires from 84 to 98 platform men to handle the crowds on the platform at Times Square and from 57 to 77 at Grand Central. The fare is still five cents although the average in cities of 25,000 and over in 1925 was 7.59 cents and still higher in 1926.

A trained personnel and an excellent roadbed contribute to this high operating efficiency, but the greatest factor is undoubtedly the rigid system of inspection and maintenance. Inspection shops are located at the principal terminals. When a car has been operated 1,000 miles it is thoroughly inspected and parts adjusted. Major repairs such as car body repairs are made at the main shops at 147th street and Seventh avenue, Manhattan. These shops have recently been modernized and enlarged and are counted among the largest and best equipped in the country for handling car repair work.

The main shops are divided as follows: Car shop for light repairs, air room for air brakes and car air compressors, electrical repair shop, machine shop, truck shop, wheel and axle shop, babbitt room, blacksmith shop, car shop for heavy repairs, wood-working mill, paint shop, inspection shop and the main shop air compressor room and room for hot water circulating equipment for heating plant.



Corner of Light Repair Shop, Interborough Rapid Transit Company

The light repair shop has eight tracks with pits, each track having capacity for five cars. The pits are heated, lighted and equipped with compressed air lines and power lines for electrical testing. This shop is served by two overhead runways with two bridge cranes each. These cranes have cages for the operators and an approximate span of 66 feet with a capacity of 25 tons each. The largest overhead monorail system in the country with an extensive switching system serves all shops with six 4-ton capacity cage operated electric hoists. In fact the traveling cranes and monorail system in these shops have been developed to a point of great speed and efficiency in handling car bodies, trucks and motors, wheels, etc.

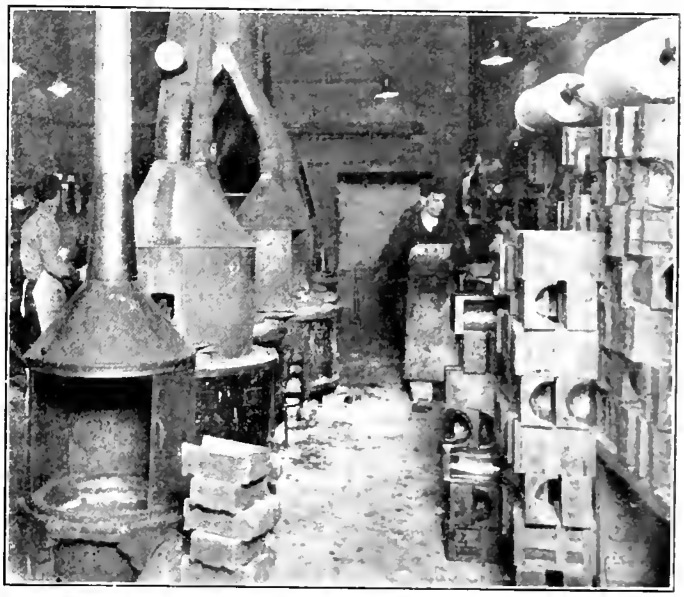
The car bodies are lifted by the 25-ton cranes and placed on blocks. The trucks are then rolled clear of the car bodies and carried over the tops of the cars by the 25-ton cranes and lowered in the truck shop located at one end of the same building, where they are overhauled on eight tracks with pits, which are continuous with those in the car repair shop, having a total capacity of 92 trucks.

For the rapid and efficient handling of heavy truck parts, such as wheels and axles, motors, etc., each track in the truck shop is provided with an overhead runway on which is operated two 3-ton capacity bridge cranes with spans varying from approximately 11 ft. 0 in. to 16 ft. 0 in. A total of sixteen of these cranes serve this shop, which with the overhead monorail system at each end reduces the labor for handling material to minimum.

Just outside the truck shop a 30-ton capacity transfer table with 25 foot span travels past all tracks in truck shop which is used to shift trucks from one track to another.

The air room, machine and electrical shops are located on the southerly side of the car repair and truck shop building. In the air room repairs are made to the air compressors and air brake equipment and this department is thoroughly equipped with all modern machines and tools for the overhauling and rebuilding of these parts. There are also a number of gas-heated hot water tanks for cleaning purposes, and gas burners are used for melting and running an insulating compound around the brush holders of car motors. A modern up-to-date switchboard with ammeters and switches, controls the testing of the repaired compressors with the minimum delay and elimination of risk to the tester.

The electrical shop is completely equipped with the most modern apparatus for the complete overhauling and rebuilding of electric motors and electric control equipment. A unique feature in this department is the suspension of a line shaft for driving various machines from brackets on the wall instead of from the roof trusses. This shaft is operated by a 30-horsepower motor. There are six regular gas-fired soldering furnaces with hoods for removing fumes, eight heavy duty gas-fired soldering furnaces for various soldering jobs and two gas-fired soft metal furnaces, one for soldering and the other for tinning. Close by is the department in which repairs are made to the door operating apparatus, which is served with gas-fired cleaning tanks. Two overhead monorail tracks are provided to serve the armature stands and the armature banding machines.



Babbitt Room Showing Row of Gas-Fired Soft Metal Furnaces

A most modern and completely equipped machine shop is provided for the maintenance of car bodies and trucks. Among the various machines are noted four turret lathes which turn out bolts up to 3 inches in diameter. Some 60 per cent of the various machines in this shop are operated from line shafts, which are driven by three 45-horsepower motors, while the others have individual motor drive. In place of the usual cumbersome method of supporting line and counter shafts by timber work, which must be changed or replaced whenever a shaft is moved, a modern system of steel construction is used which can be shifted as desired in relocating machinery without loss of time or expense for alterations or new material.

A gas-fired steam boiler is provided with an automatic control which maintains a constant and uniform steam pressure and water level at all times and without the attention of an operator. This boiler is used in the machine shop for blowing dirt and grease from motor housings. Close by is a hot water cleaning tank 9 feet long and 4 feet wide and deep. The heating apparatus for this tank consists of a single pipe coil placed inside and near the bottom with the flange bolted on the outside. A pressure gas burner fires directly into the coil, through the flanged opening while the other end of the coil rises through the water and connects with a pipe which discharges the products of combustion outside the building.

A building adjoining the repair and truck shops, on the northerly side, houses the wheel and axle shop, babbitt room, compressor room and heating plant. Wheels are received from the steel mills with treads finished to size and rough bored. The bores are fitted to axle and the wheel is pressed on by a 400 ton hydraulic wheel press, two of which are in this shop. Four vertical boring mills are used to finish bore the wheels. The boring mills are also used to bore out armature shaft bearings after they are pressed into housings, the housings being held in special heavy cast iron jigs.

Wheels with worn treads are turned, mounted on axles in four 42 in. center drive wheel lathes. Axle journals that require turning are machined with wheels mounted on axle in two 36 in. engine lathes, motor driven.

Corner of Electrical Shop Showing Gas-Fired Soldering Ovens and Portable Soft Metal Furnace

A spring testing machine is located in this shop which is used for periodical testing of truck springs.

The babbitt room contains 10 soft metal furnaces two of which have 26 inch pots and the rest 20 inch pots. Here is carried on the work of babbitting axle linings, which is accomplished by placing the axle linings and journal brasses in moulds and pouring in the melted alloy to the depth of 1/16th of an inch. These furnaces are heated by gas which has been raised to about three pounds pressure by a special blower and entrains the right amount of air for complete combustion. The gas is automatically regulated to obtain a uniform temperature. Pyrometers are furnished for checking up the temperatures and an exhaust fan removes the fumes through hoods and exhaust pipes. A unique safety device in the form of an automatic shut-off valve on the gas line is supplied. If for any reason the gas booster motor should fail this valve will automatically cut off the gas supply. Strict orders are in force to turn off the gas valves of each furnace before resetting the automatic emergency valve. In this way the accumulation of too much gas in any one combustion chamber prior to lighting is obviated.

North of the wheel shop are located the shop for heavy car repairs, the woodworking mill and the blacksmith shop. The latter is one of the most up-to-date in the country and contains ten, latest model, down-draft Buffalo steel forges. Blower and exhaust are direct connected to one motor and the piping system consists of tile pipe set in solid concrete, below the floor, with cleanout manholes at suitable intervals. All piping leads into a common soot pit and smoke and fumes are thus eliminated. In fact, this department embodies the last word in blacksmith shop construction and the atmosphere is more like that of a well regulated hotel. Among other machines in this shop are noted an air operated 800 pound steam hammer, a motor driven 125 pound Bradley hammer and a punch and shear capable of shearing 10 x 1½ inch steel plates.

The heavy repair shop has four tracks with pits having a capacity of 20 cars. The heavier body repair work is done here. In conjunction with all departments a welding shop with four electric welding machines repairs all broken parts and restores worn surfaces.

The subway cars being of steel construction, the carpenter shop is limited in size and equipment and is only provided with the necessary woodworking machines for turning out wooden contact shoe beams used on the car trucks and for seat repairs. The paint shop where the cars are painted, is provided with five tracks and pits capable of holding approximately 45 cars and is served with an overhead bridge crane of 25 tons capacity.

Compressed air for all shops is supplied from the compressor room where are located two compressors of 1,300 cubic feet capacity each, each driven by a 110 horsepower motor. The pressure is maintained at from 90 to 100 pounds per square inch.

Another unique feature of these shops is the floors which have an 8-inch concrete base upon which 2½ inch creosoted wood blocks are set on end. This type of floor has been found to be much more serviceable and cheaper to keep in repair than any other.

Increasing Use of Steel Passenger Cars

The increased use of steel in passenger cars and corresponding reduction or retirement of wooden cars from service is shown in a recent report of the Bureau of Railway Economics.

The following table gives the various types of passenger equipment installed and retired during the year of 1926:

Type of Equipment	*No. Installed*	*No. Retired*
All-steel cars	2,494	170
Steel under-frame cars	374	247
Wooden cars	211	2,461
Total	3,079	2,878

In other words, with the exception of 417 cars, the retirements last year were all wooden cars. The net increase is 2,324 all-steel cars and 127 steel under-frame cars. The net decrease is 2,250 wooden cars.

On December 31, 1926, the railroads had on order 727 new all-steel cars and 3 steel under-frame cars. No wooden cars were on order.

When these cars which are on order are delivered, and are accompanied by further retirements of old cars, the percentage of steel equipment will be considerably increased, and that of the less modern equipment will be still further decreased.

This process continues steadily month after month. At the rate which is now being maintained, all-steel and steel underframe cars will continue to far outnumber all the wooden cars still in service; this does not mean, of course, that conditions on many branch lines and on many railroads will not justify the continued use of wooden cars.

On December 31, 1926, the passenger-train equipment of the railroads totaled 54,226 cars. Of this number 23,268 were all-steel cars, 9,506 were steel under-frame cars, and 21,452 were wooden cars.

The Manufacture of Solid Rolled Steel Car Wheels

By G. A. RICHARDSON, Bethlehem Steel Company

Rolled steel wheels present an excellent example of a product comparatively simple in appearance and section, which requires special equipment for their manufacture. Much loss in production time will accrue when changes in design are made. While the details of method in producing rolled steel wheels vary somewhat with the different manufacturers, the essential conditions remain identical.

There is no "hit or miss" about wheel making methods. From the time the materials go into the open hearth furnace until the finished wheels are produced, wheels and wheels only have been under consideration. The open hearth heats are selected as to charge for wheel making purposes and are specially handled throughout the refining process. Should any abnormality develop during the refining process, the heat is rejected, as far as being used for wheels is concerned. Every attention possible is given to slag and temperature control and other metallurgical features involved in the manufacture of steel.

The steel is cast into large ingots which are rolled in a 32-in. mill to round blooms of a diameter to suit best the size and type of wheel to be made. The blooms are sheared hot with rotary shears into blocks of desired length.

The problem of standardization is not a serious one as far as the steam railroads are concerned. They adhere to about nine types of wheels at present as compared with more than 360 types used by electric railways. The standardization has enabled the manufacturers to carry large stocks of material on hand always, which aids in making prompt deliveries. This seldom is possible where a large variety of special and little used sections are needed.

It is customary to carry 5,000 tons or more in stock of sheared blocks of sizes which are standard and frequently used. These blocks are suitable only for the certain type of design of wheel for which they have been sheared. It is impracticable to stock blocks for types of wheels seldom required. In these cases it becomes necessary to roll and shear material to order, which, of course, is a source of delay and means additional expense.

Wheel blocks, when cold, are all carefully inspected by inspectors independent of the manufacturing department and those found suitable for wheels are chipped and again inspected before they are charged into the furnaces. The blocks are weighed. The weight is checked in order to provide uniformity in the finished product.

In the conversion of the block into the finished wheel it should be borne in mind that, regardless of all other costs, the overhead charge on equipment, that must lie idle while changes are being made, is not a small one and mounts up very rapidly. Furnaces must be kept up to temperature, with the consequent consumption in fuel. The output is reduced. The above charge does not take into consideration the cost of dies or rolls that must be used, but merely the basic equipment such as presses, wheel mills and pumps. When a new type of wheel is to be made a complete change of rolls and dies is necessary. A full set of equipment for one type of wheel involves an outlay of from $1,000 to $1,500. This may be modified somewhat, depending entirely on the design of the wheel.

It is necessary not only to make a complete change of tools for all types of wheels, but it is imperative also to carry certain repair parts in stock. The total weight of tool equipment such as rolls, dies, carried in stock amounts to nearly 2,500 tons, the greater part of which is idle at any other time. This means an overhead charge of several million dollars, which could be reduced materially, if it was not for the large number of types of wheels being specified in certain territories. If the same degree of standardization were maintained in electric railway work as in steam railway practice, a few hundred tons of dies and rolls would suffice. This is only one of a number of facts to be emphasized in showing the advantages of standardizing design as far as possible.

The layman is not likely to realize the large number of parts involved in the set-up for a given type of wheel. More than 25 separate parts must be changed for every new line-up weighing from a few hundred pounds up to as much as 6,000 pounds apiece. From these figures alone it can be understood that the time element involved in making a complete change is considerable.

Any change in diameter or width of rim of wheel necessitates a complete change of dies throughout, with the single exception of those used on the punching press. When the diameter and run width remain the same but hub diameter or rim thickness vary, a change of die pleates is necessary. As a matter of fact this really is equivalent to changing dies, so far as the time element is concerned, because the dies must be loosened from their fastenings to permit the assembling of the plates. Die plates for all standard wheels are carried in stock, but any departure from standard necessitates machining new ones. In many cases, due to the use of a standard counterbore, it is possible to use the same die plate in more than one die. In general, the weight of the dies remains fairly constant. In other words lighter wheels do not mean much lighter dies.

Steps in Manufacturing

Five distinct operations and three heats are involved in the rolling of wheels. The blocks are brought to a forging temperature and then undergo a first forming under a 12,000 ton press. After reheating a second operation under a press of same capacity follows. After this operation follow hub punching, a third heating, rolling in the wheel mill, and a final forming operation in the coning press. After a slow, uniform cooling the wheel is ready for the hot bed inspection, machining, final inspection and shipping.

Blocks which have successfully passed the final inspection as to weight and quality are changed into a 70-ft. continuous furnace, through which they roll slowly before reaching the final hearth, which provides for a gradual and uniform rise in temperature. This gives every assurance against thermal cracks which might result from charging the hard steel directly into a hot furnace. It takes 3 to 3½ hours for one of these blocks to pass through the first heating furnace. From these figures it is evident that a very uniform and closely controlled forging temperature is available.

After this heating comes the first forging operation. In this the block is upset or flattened, and part of one hub and web started. Two dies, two web plates and an extractor are required. For a 33-in. freight car wheel the bottom roughing die weighs about 6,000 lbs., the top roughing die 4,500 lbs., the top web plate 700 lbs. and the bottom web or die plate 100 lbs. The time required for changing dies at this press is about one-half hour and requires a crew of four men, including the crane man.

One of the most important things in the first forging operation is to have the block centered accurately in the die in order to obtain an accurately forged blank. This is necessary to produce a uniform forging. The centering is accomplished by mechanical means and prevents underfills and overfills. These would cause surface defects and eccentric forgings in the later operations.

The first forging blank is reheated to forging heat, the scale blown off, and it is taken to the second forging press. This is a 12,000-ton capacity press, used to form the other side of the web, hub and also the flange. The second forging resembles a wheel in shape but the diameter, in the case of a 33-in. car wheel, is about 4 inches smaller than that of the finished product and the web is much thicker. In the second operation top and bottom dies are required with top and bottom web plates and extractor. The weights and changing time are practically the same as in the case of the first forging press. The only difference is in the shape of the top die and contour of top web plate.

A hub punching operation follows immediately. The same dies are used for different diameters of wheels. A change is necessary only when the hub diameter varies. When the length of the hub varies, it is taken care of by liners which raise or lower the blank. The parts required are punch, mandrel, and top and bottom punch dies, weighing about 200 to 300 lbs. apiece. The time necessary for changing dies at the punching press will average about 15 minutes, a press operator and two helpers being required.

After the pressing and punching operations, the wheel is charged into a third furnace brought to the proper temperature, and then taken to the wheel mill for rolling. This makes a total of three heatings in producing a wheel, an important thing to bear in mind. It insures the best possible conditions as to plasticity of the metal and uniformity of temperature throughout the complex section of a wheel in the various forgings and rolling operations. Frequent heatings are necessary in reducing stresses to a minimum which might be set up by temperature differentials, if such existed.

In the wheel mill the blank is rolled out to the final diameter and web thickness. Five rolls do the actual rolling while a sixth or guide roll is provided to keep the wheel from wabbling in the rolling operation. The rolls that do the work include a back roll, two web rolls and two edging rolls.

The back roll must be changed for any variation in rim width. The roll can be taken out without removing the front, the total time required being about one hour. It is a grooved roll, used to form the flange and tread, and is mounted so that it is free to rotate but not driven, except by frictional contact. It does not change its position during rolling, although it can be adjusted. The entire back roll housing can be moved back and forth to set to proper relation with web rolls.

The edging rolls support the edges of the wheels. They can be pushed in and out by mechanical means but are not driven rolls. They are never changed except for replacement. The two web rolls are the driving units which work the web to the desired section. They are driven by a motor drive and in turn rotate the wheel while they are working out the web. Change of web rolls becomes necessary only in cases where the distance between the inside edges of the rim and the hub is different. The centering of wheels is a great advantage in use as well as in the actual coning operation.

A complete change of rolls requires about 1½ hours, a time which is comparatively short due to the use of the patented, removable front on the mill, which gives ready access to the web and back rolls. Changing the web rolls requires practically as much time as a complete change of all rolls. When the web rolls are removed the back roll can be taken out at the same time. Back rolls weigh about 225 lbs., while the web rolls, complete with shanks and flange, weigh about 1,500 lbs. each.

Next operation is the coning or dishing, which is performed in a 4,000-ton coning press. The wheel is also sized at the same time and one of the features of the Bethlehem method of manufacture is that solid, instead of segmental, dies are used. This insures great accuracy in the size of the wheel. The steel is of such a uniformly good grade that approximately 65 to 94 per cent of freight car wheels produced daily represent wheels on which no machining on the tread is required.

In the coning press, top and bottom dies, and top and bottom web plates are used. The time for changing dies will average that required in the case of the first and second forging operation.

Inspection and Machining

The ingots are rolled lengthwise into round blooms. If there is any segregation in the ingot it is in the middle part and it remains there as a result of the method of rolling. The blocks are sheared from the bloom at right angles to the longitudinal axis so that any segregated material still remains in the center, a fact which holds true throughout the various operations in forming the wheel. The result is that such segregated material either is disposed of in the hub punching or what little remains is in the hub, where it can do no harm, whereas the best metal is at the rim, where the most work has to be done.

After the coning operation the wheels are transferred to the hot bed where they are stacked and allowed to cool slowly. As soon as cool a thorough hot bed inspection is given them and then machined according to the requirements. Complete machining consists of machining the tread, face inside rim, and boring and facing the hub. These operations are now performed on a new wheel turning mills provided with roughing, finishing and boring head, rim facing and wear line head. On the first set-up all work is done but the facing of the inside hub and the boring, which are performed on the second set-up. Solid contour tools are used which gives absolute fit and smoother machining on a rough turning job. If wheels are to be placed in stock the boring of the hub is omitted, as minor variations in required diameter can be taken care of as orders are received.

At Bethlehem it is believed it would be a good thing if users of wheels realized more fully the advantages of accepting wheels "rolled to finish." Contrary to the belief that it is the manufacturer who gains because of the saving in machining, the facts are that it costs more to make steel of the high quality required to go through the severe forming operations without developing small tears and flaws. The presence of any of these would necessitate machining. Furthermore it costs more to maintain the equipment at the high standard. Hence, the manufacturer is not making any appreciable saving whereas the customer benefits by getting better material and longer service of the wheels.

It is safe to say that under average working conditions die changes will cause a loss of 10 to 15 per cent in the output, a figure which is not a small one by any means, and very definitely influences costs. At the plant described from 5,000 to 7,000 tons of wheels of standard sizes are carried in stock and these can be bored to meet customers' requirements. No manufacturer, however, can afford to carry a stock of wheels of sizes and types infrequently specified.

Rock Island Gas-Electric Motor Cars

Develop 550 hp. and Burn Low Grade Distillate

A fleet of six cars, representing an entirely new type of gas-electric motive power, burning a petroleum distillate, will be exhibited to the public by the Rock Island Lines, at St. Louis, April 15; Kansas City, April 17; Des Moines, April 19; and Chicago, April 21. During the week of their exhibition, the cars were operated as a single train under its own power, making brief stops at the towns between the four principal cities mentioned, in order to give the public an opportunity to see this new type of rail motor transportation.

An important feature of the new motor cars is the fact that each unit is capable of pulling one or more regular passenger cars, thus making it possible ultimately to substitute this character of motive power in place of steam locomotives on many local trains of the Rock Island throughout the Middle West.

The passenger cars are of the same width as a standard Pullman, and are equipped with vestibules. They will seat 77 passengers each. The exterior of the cars are finished in olive green and the inside trim in mahogany.

Motor Baggage Car of the Rock Island Lines

The engine room in the front end is 10 feet long. Next are the baggage or express space of 11½ feet, and a smoking compartment 9 feet long. The main compartment of the car is 38 feet long. Upholstery is of imitation leather.

The car is finished with Duco lacquer of olive green color, the Rock Island standard. The inside trim is of Honduras mahogany, natural finish. Ample basket racks are conveniently located for the passengers. Toilet and drinking fountain facilities are located in the rear end of the main passenger compartment.

The car is heated with the American Radiator Company Arcola hot water system. The electric current for the lighting is supplied by the main power plant and storage battery. The window sashes, of brass, afford excellent vision for the passengers, and are easy to operate. The cars are also equipped with storm sashes for use during cold weather. Battleship linoleum with metal binding is used in the aisle, and the vestibule floor is covered with rubber tiling similar to that used for Pullman sleepers. The car is equipped with all standard safety appliances. Two Strombos horns are used. The car trucks are of cast steel type, the frames being of one piece as furnished by the Commonwealth Steel Company of East St. Louis.

The power plants have sufficient capacity to enable the cars to pull one trailer each. The trailers—baggage or mail, or combination—are original Rock Island cars which have been converted to meet the requirements of motor trailer cars. They are also equipped with hot water heating systems and electric lights, the current for which is obtained from train line connection with the motor cars.

Inasmuch as the railway company had several cars that could be used for express or baggage, it was felt that the steel motor cars should be so designed as to carry the passengers. At the same time, in order to prevent possible obsolescence of the equipment, the motor cars were so designed that a mail compartment can be installed whenever it should be desirable; for the same reason the cars were so designed that a second 275-horsepower engine can be installed, thus making it possible to haul more trailer cars or, in some instances, to handle freight cars.

The cars were built in an endeavor to furnish communities served by the Rock Island with a high grade of local passenger, mail and express service, and yet to do so at less cost than that necessary for furnishing steam service.

In addition to the five passenger cars, the Rock Island in its own shops at Horton, Kansas, has completed the conversion of two 40-foot 45-ton steel cars into two gas-electric units, each being equipped with two sets of 275-horsepower units, the motors being designed with sufficient capacity for use in continuous low-speed heavy freight service. These power plants are so built and installed that they can be controlled as one unit, with a total capacity of 550 horsepower. The engine man is able to run one or both power plants to meet the schedule requirements, cutting the power plants in or out as may be necessary for capacity and economy. One power plant handles the motors on the forward truck; the second one handles the motors on the rear truck. Twenty of the 40 feet in the car are left for revenue service.

The cars as converted weigh approximately 75 tons each, and are designed for pulling two or three trailer cars in regular local passenger service. One of these two cars was first equipped with a low gear ratio so as to carry on some experimental work to determine their adaptability for light switching and light local branch line freight service. Upon completion of the experiments, the low ratio gears were replaced with standard passenger gears, as the cars are to be used in local passenger service.

As in the case of the five larger cars, these converted cars or motor car power units furnish the electric current for lighting the trailer cars. The trailer cars as well as the motor car power units are heated by hot water systems.

The Rock Island Lines is the first railroad to substitute motorized power for both passenger and light freight service on branch lines.

The cars are of a new type which burn as fuel a petroleum distillate such as is used in residence oil furnaces. According to E. Wanamaker, electrical engineer of the Rock Island Railroad, the cars will solve the biggest problem now confronting the railroads of the middle west, that of economic and successful handling of traffic on branch lines.

In addition to their operating economics, the new cars afford a cleaner cab, are easier to operate, vibrates less than a steam locomotive, and require less attention.

Railway and Locomotive Engineering

A Practical Journal of Motive Power,
Rolling Stock and Appliances

Published Monthly by
ANGUS SINCLAIR COMPANY
136 Liberty Street, New York
Chicago Office: 168 North Michigan Avenue
Telephone Rector 0746. Cable Address "Locong." N. Y.

Harry A. Kenney, Prest. and Man. Ed. J. Snowden Bell, Associate Editor
W. E. Symons, Associate Editor Thomas P. Kenney, Secretary

LONDON REPRESENTATIVE
The Locomotive Publishing Company, Ltd., 3 Amen Corner, Paternoster Row, London, E. C., England.

SUBSCRIPTION PRICE

$2.00 *per year,* $1.00 *for six months, postage paid in the United States, Canada and Mexico. For other parts of the world,* $2.50. *Single copies,* 20 *cents. Remit by Express Money Order, Draft, Post Office Order or Registered Letter.*

Mailing address can be changed as often as necessary—always give old and new address, and if you subscribe in a club, state the name of the agent.

Please give prompt notice when your paper fails to reach you regularly.

Entered as second-class matter January 15, 1902, at the post office at New York, New York, under the Act of March 3, 1879.

Economies Effected by the Use of Anti-Friction Bearings

In another column of the present issue is a highly interesting and valuable contribution on the economies effected by the use of anti-friction bearings on railway rolling equipment.

During the past few months we have presented to our readers a number of articles on this important subject, but have not until now had a complete and comprehensive report of the results obtained in actual service, such as is embodied in the study referred to above, which was made on the Chicago, Milwaukee & St. Paul Railway.

The possible economies resulting from the use of roller bearings on a twelve car train in suburban service as covered by the report are based on the results of the operation of a much smaller number of cars with a locomotive of ample capacity to accelerate the shorter train to required running speed in time allotted by the schedule. It therefore follows that if the train had actually consisted of twelve cars, with an engine of a capacity to meet the schedule only under more favorable circumstances, then, and in that event, the resulting economies would have been far greater than those shown in the report. It is under the latter condition that the yard stick should be applied in measuring the true value or real merits of the roller bearing in railway service. It would seem that the sponsors or endorsers of this improvement in railway equipment have not overlooked the "power and eloquence of modesty or underestimation."

It has been suggested by a French engineer that the suction at the rear end of a train may be equal to the resistance to be overcome from the air pressure at the front end, particularly at high speeds. Should it be found, after investigation, that the factor is even approximately what has been suggested, then, regardless of the type or kind of journal bearing used, we will find it necessary to revise our rules, formulæ and practice with respect to the drawbar pull necessary to move trains, particularly at speeds where the atmosphere or air resistances are a more important factor.

We would welcome contributions on this important phase of railway engineering.

Scale and Corrosion in Locomotive Boilers

On account of its form and comparatively high evaporation per unit of heating surface, the locomotive boiler is peculiarly subject to the formation of scale and particularly so if the feed water is hard.

This has a direct effect on the efficiency of the locomotive as the scale formations on the surfaces of the tubes and boiler act as an insulating material. Sections of the boiler round the firebox are particularly susceptible to the scale formations and exposes them to the dangerous effect of burning out. These incrustations in a locomotive boiler are due to the precipitation of mineral substances or to the settling matter held in suspension by the feedwater.

Prevention of scale should always be aimed at, and not merely removed from time to time after it has already formed. Systematic treatment of the feedwater should be carried out wherever necessary, together with frequent washing out of the boiler with a good force of hot water to remove sludge deposits or salts due to concentration in the boiler. Accumulations of sludge round the foundation ring should be especially guarded against by thorough washing out.

The structural form of some boilers admit of comparatively easy scale removal and as a result their users persist in the use of bad, untreated waters and then as occasion demands put the boiler out of service for scale removal mechanically. This can hardly be considered good or efficient practice. Such waters as contain salts which are liable to form scale can be readily rendered inocuous by the addition of boiler compounds which act chemically and break up the scale as it tends to deposit, the impurities being converted into slude which gravitates to the bottom of the boiler, from whence it may be removed by blowing down and by washing out.

In some places the feedwater supply is slightly acid, owing to its flowing over mineral or vegetable matter, and such waters have a rapid corrosive effect on boilers unless the acidity is counteracted by the addition of an alkali compound in the tank or boiler.

Corroded and distorted boiler sheets has been experienced on nearly all railroads and the tendency to increase boiler pressures has aggravated the problem. The experience of most motive power men has been that every increase in boiler pressure has brought an increase in boiler troubles. While there is a difference between substances, it has been established as a general law that where there is a tendency to corrosion or chemical action, substances, as between iron and steel plates and water that may have ingredients or salts that tend to corrosion of such plates, the rapidity of such chemical action doubles approximately for each ten degrees rise in temperature and pressure.

The locomotive boiler with its tubes and small waterspace round the firebox, is practically uncleanable by hand or mechanically from within the boiler. Obviously, the best method is to attack the problem at the outset.

The chemical treatment of boiler feedwater is an established science. Chemists take samples of water from season to season, determine to an exact degree the tendencies of the various salts or other impurities have to scaling, foaming, pitting and corrosion, and prescribe and construct formulas to overcome or render harmless such impurities in waters, suiting the prescription and manner of feeding the treatment to the operating requirements of the road.

The feedwater for the majority of the locomotives in service in the United States is subjected to this scientific treatment, which experience has shown results in a high degree of economy, as maximum train tonnage can be maintained due to increased boiler efficiency, a substantial saving in fuel is effected with reduced maintenance expense items of motive power.

The Actual Cost of Locomotive Fuel

Elsewhere in this issue will be found a highly interesting paper by L. K. Sillcox, General Supt. Motive Power of the Chicago, Milwaukee & St. Paul Railway entitled "What Is the Actual Cost of Locomotive Fuel."

The terms, "price paid," "cost," etc., are often used rather loosely and unless they are clearly defined mean little or nothing. The purchase price or first cost represents the primary original investment, but it is only one of the factors in the actual or ultimate expense involved, and Mr. Sillcox's treatment of the items of locomotive fuel expense brings these features out so clearly that it should be a comparatively easy matter to prepare a properly sub-divided and correct cost sheet of the expense of locomotive fuel.

It will be noted that the cost or purchase price of locomotive fuel for the Class One railways in the year of 1925 was $415,906,944, or $3.132 per ton, but that the actual expense to the railways after inclusion of the several items properly chargeable to this account brings the bill up to $574,422,445, an increase of $158,515,501 in the sum total, an increase in the price per ton from the purchase price of $3.132 to $4.325.

Another important factor of the question is the cost per ton of fuel actually employed as useful energy at the drawbar of the locomotive. Based on an efficiency of 8 per cent, the price or cost of the fuel used is $54.13 per ton. Therefore, if the efficiency of the prime mover could be raised or increased to a degree that would give 10 per cent, the cost per ton of fuel employed in doing useful work would be reduced from $54.13 to $43.30 per ton and would obviously mean the saving of millions of dollars each year.

A careful study of the able analysis which Mr. Sillcox has prepared of the actual cost of locomotive fuel prompts us to remind those interested in the general problem of railway economics, that when "Alexander the Great" sat down and wept that there were no more worlds to conquer, he had only scratched a little around the edges of the habitations of man.

Smoke Abatement and Fuel Economy

The performance of locomotives is largely dependent on their maintenance and while it is not possible to maintain them in perfect condition at all times, the highest possible standard should be set up as a mark to shoot at and an earnest effort made at all times to hit the mark. Good coal and properly designed and well maintained locomotives are essential to economical operation, but the results that can be obtained in smoke abatement and fuel economy depends principally on the human element.

Black smoke is an indication that for some reason the combustion is incomplete, consequently a direct fuel loss is occurring and the blacker the smoke, the greater is the fuel loss through the escape of unburned gases. However, the absence of smoke does not necessarily mean complete combustion or the elimination of waste of unburned gases, as the stack may be cleared up through excessive air dilution. There are instances in the operation of locomotives when it is necessary to admit an excessive amount of air in order to clear the stack and then smoke abatement is effected at the expense of the coal pile. This, however, is not an argument against smoke abatement. While the abatement of smoke in some instances may result in an increase in the fuel consumption we can't get away from the fact that smoke is an indication of incomplete combustion, a fuel waste. Therefore, fuel economy effected by the perfect combustion of the coal will result in smoke elimination. Perfect combustion should, therefore, be the goal and the fact that it is a difficult problem should encourage all who are interested in successful and efficient railroad operation to be persistent in their efforts to attain this goal.

What a Railroad Buys

Part of the Pennsylvania Railroad's contribution to the record-breaking national prosperity of 1926 is revealed in the compilation of purchases of fuel and materials made during the year. The total expenditures for these purposes were $164,049,700 and embraced practically every product of farm, factory, mill and mine known to American commerce, ranging from milk, eggs and toothpicks for the dining cars to rock ballast, locomotive coal, rails, ties and structural steel.

This total, while not including large expenditures for new cars and engines, which were in excess of $24,000,000, amounted to approximately 25 per cent of the Company's gross operating revenues. The purchases made from some 7,500 individuals, firms and corporations, were classified under about 75,000 separate items, and represented 520,111 sellers' invoices.

Iron and steel products contributed the largest group total. These industries benefited during the year to the extent of $57,647,206 from Pennsylvania Railroad purchases. Of this amount, $9,533,263 was spent for 216,665 gross tons of steel rails and $9,713,187 for frogs, switches and rail fastenings. Wheels, axles and tires took $4,647,155 and flues and tubes for locomotives $1,603,678. The balance represented purchases of an immense variety of iron and steel products of almost every conceivable kind turned out by these industries.

Fuel purchases aggregated $37,086,879, of which $36,202,878 was spent for 18,306,755 net tons of bituminous coal. Fuel oil to the amount of 15,020,219 gallons cost $78,561. The remainder was spent for relatively small quantities of anthracite coal, coke, wood, etc.

Expenditures for forest products totaled $13,352,981, of which $6,986,168 represented the total purchase price of 4,783,927 crossties. Timber and lumber, the next item in importance under the heading of forest products, totaled $4,151,003.

Miscellaneous items included $7,867,366 for electrical materials, $2,859,447 for lubricating oils and grease, illuminating oils, waste, etc. Ballast to the extent of 1,923,792 cubic yards represented a cost of $1,811,843. Air brake material absorbed $2,844,263. Even the stationery and printing trades, usually thought of as having little direct connection with the furnishing of transportation, were beneficiaries to the extent of $4,220,665, representing the cost of printing time-tables, special notices, etc., as well as stationery required in the conduct of the Company's business.

The International Railway Fuel Association Holds Annual Convention

Papers and Discussions Cover Every Phase of Railroad Operation Relating to Purchase, Storage and Use of Railway Fuel.

The nineteenth annual meeting of the International Railway Fuel Association was held at Hotel Sherman, Chicago, May 10 to 13, inclusive. Features of the opening session were the addresses by Carl R. Gray, president of the Union Pacific System; George Otis Smith, director of the United States Geological Survey, and Dr. H. Foster Bain, secretary of the American Institute of Mining and Metallurgical Engineers. Mr. Gray in his address called attention to the changed attitude of the public as reflected in the press due to the publicity given to railroad difficulties and accomplishments, which is also reflected in a more sympathetic and considerate attitude on the part of administrative and regulatory bodies. Mr. Smith in his address, "What Price Distance," said that the conquest of the distance is the big task set before the railroad men. Dr. Bain pointed out that 30 per cent of the bituminous coal and 5 per cent of the anthracite coal mined in this country is used by the railroads and more than 52 per cent of the freight handled comes directly from the mines.

During the convention other addresses were made by T. H. Williams, assistant general manager of the Southern Pacific Company; N. B. Ballantine, assistant to the president of the Seaboard Air Line Railway; L. K. Sillcox, general superintendent of motive power of the Chicago, Milwaukee & St. Paul Railway; E. E. Regan, general superintendent of the New York, New Haven & Hartford Railroad; H. S. Rauch division superintendent of motive power New York Central Railroad; and F. S. Wilcoxen president, International Railway Supplymen's Association. Some of the principal reports of the committees are given in full or in abstract on this and the following pages.

New Locomotive Economy Devices

With the increasing number of new locomotive economy devices, to which this committee is giving attention each year, it is necessary to give some consideration to the overall effect of a number of these devices applied to the same locomotive. The improved performance of a number of new locomotive designs recently tested on several railroads reflects in a large measure the combined effect of an aggregation of devices most of which have come into practical use on American locomotives since the advent of the feed water heater which is the first device to which this committee devoted its attention.

A good example of this can be found in the performance of 15 locomotives with Feed Water Heaters, Superheat for auxiliaries, Boosters, rail-washers, Thermic Syphons, limited cut-off and designed for 250 pounds working pressure, with enlarged grate area and four-wheel trailer-trucks, compared under the same operating conditions with the performance of 36 locomotives of similar type (2-10-2), designed for a working pressure of 200 pounds and not equipped with the devices and features above referred to.

Both groups of locomotives have five sets of drivers, 63 inches in diameter. The cylinder dimensions of the newer locomotives are 29 by 32 inches compared with 28 by 32 inch cylinders on the older locomotives. The new locomotives designated as the Texas Type weigh 150 tons on drivers compared with 133 tons weight of drivers of the older locomotives.

The Committee is indebted to the Texas & Pacific R. R., for the following statistics covering the operation of both groups of locomotives for the calendar year, 1926:

		Texas Type	*2-10-2 Type*
Marshall	Total Mileage	8542	33811
	Average tons per train mile	3005	2497
	Per cent engine utility............	62.6	73.4
	Gallons oil per 1000 G. T. M.	6.9	11.2
	Compared with 2-10-2 *Type*:		
	Per cent reduced fuel consumption	38.4	.....
	Per cent increased train loading	20.4	.....
Longview	Total Mileage	3529	133766
	Average tons per train mile	2899	2181
	Per cent engine utility	85.3	82.3
	Gallons oil per 1000 G. T. M.	6.4	10.5
	Compared with 2-10-2 *Type*:		
	Per cent reduced fuel consumption..	39.0	.....
	Per cent increased train loading....	32.9	.....
Dallas	Total Mileage	90367	331525
	Average tons per train mile	2390	1854
	Per cent engine utility	79.7	84.3
	Gallons oil per 1000 G. T. M.......	6.9	10.7
	Compared with 2-10-2 *Type*:		
	Per cent decreased fuel consumption	35.5	.....
	Per cent increased train loading ..	28.9	.....
Ft. Worth	Total Mileage	191237	203581
	Average tons per train mile	2244	1617
	Per cent engine utility	78.1	78.9
	Gallons oil per 1000 G. T. M.	7.3	12.3
	Compared with 2-10-2 *Types*		
	Per cent reduced fuel consumption..	40.6	.....
	Per cent increased train loading....	38.8	.....
Baird	Total Mileage	168653	67341
	Average tons per train mile	2224	1546
	Per cent engine utility	67.4	65.8
	Gallons oil per 1000 G. T. M.	7.4	11.0
	Compared with 2-10-2 *Type*:		
	Per cent reduced fuel consumption	32.7	.....
	Per cent increased train loading....	43.9	.....
Total	Total Mileage	462328	770024
	Average tons per train mile	2285	1850
	Per cent engine utility	73.9	80.3
	Gallons, oil per 1000 G. T. M.	7.2	11.1
	Compared with 2-10-2 *Type*:		
	Per cent reduced fuel consumption..	35.1	.....
	Per cent increased train loading....	23.5	.....

The difficulty of finding two such groups of locomotives operating under conditions that afford a valid comparison can be appreciated and the foregoing figures are submitted with no pretence of scientific accuracy. However, it must be admitted that in the aggregate, the individual claims to efficiency for each of the several devices and features in design above considered have been substantiated, bearing in mind that as the number of such features is increased, the actual fuel saving that can be attributed to each individual device is diminished although the percentage of saving may remain constant.

Direct Steaming Locomotives at Terminals

While improvements in locomotive design and equipment are accomplishing a steady decrease in fuel consumption per 1,000 ton-miles, this saving is being accomplished almost entirely in road service since practically all of the devices and improvements in locomotive design above enumerated are effective only while the locomotive is in operation between terminals. As a result the percentage of fuel consumed at terminals is constantly rising until it is estimated by some roads to represent from 25 to 40 per cent of all locomotive fuel.

Careful attention has therefore been given to developments in the use of direct steaming during the past year. It will be recalled that the committee has previously given consideration to the direct steaming system as a new development in connection with feed water heating at terminals.

During the past year the Grand Trunk Western R. R., and the Chesapeake & Ohio Ry., have both conducted tests of the direct steaming systems experimentally installed on these roads. The installation on the Grand Trunk Western R. R., at Battle Creek, originally equipped with eight direct steaming stations, has since been enlarged to fifteen direct steaming stations with flexible connections from overhead piping to the locomotive blow-off valve. A similar installation of the direct steaming system is now being installed to serve all tracks in the Grand Trunk Western R. R. enginehouse at Chicago and the new Texas & Pacific R. R. enginehouse at Gouldsboro, La.

In the operation of the direct steaming system, locomotives are held under steam by direct connection to a high pressure steam main from a stationary boiler plant and when the locomotive boiler is emptied in the enginehouse it is refilled with a mixture of hot water and steam which flows into the boiler until a working steam pressure has been developed in the boiler without a fire on the grates. Provision is also made for salvaging surplus water that accumulates in the locomotive boiler while the locomotive is being steamed up or held under steam.

With this system it is not necessary to light the fire on the grates until the locomotive is ready to leave the terminal and if it is desired to eliminate all fires in the enginehouse, the locomotives are moved out under their own steam and placed on the ready track before the fires are ignited. Based on experience and tests of the direct steaming system under ordinary operating conditions at Battle Creek, the Grand Trunk Western R. R. have found this system to be the most practical means for smoke abatement at its Chicago enginehouse. The Chicago & Northwestern Ry. and the Big Four R. R. have completed plans for the installation of the direct steaming system on a large scale for the purpose of smoke abatement in enginehouses at Chicago and Cincinnati.

From the standpoint of fuel economy at the terminal the results depend upon the steam consumption required to steam up and hold locomotives under steam by means of stationary boilers in place of fuel burned on the grates while the locomotive is standing in the enginehouse.

In the tests above referred to it was established that from 4,500 to 6,000 lbs. of steam per hour is the maximum requirements at the time boiler is being refilled after being washed out or water changed, this figure being based on steaming an engine from empty to stationary boiler plant pressure in from one hour to one hour and twenty minutes. Provided more time can be allowed for filling and steaming the maximum steam consumption can be cut down to direct proportion to the time required to bring the engine up to maximum pressure.

Where the stationary boiler plant pressure is 150 lbs. and it is desired to hold locomotives at a minimum of 125 lbs. pressure, it has been found that a ½ inch by-pass at each direct steaming station permitted sufficient steam flow to maintain this pressure, which represents a maximum demand upon the stationary boiler plant of 30 B.H.P. per hour, it being understood that this takes care of ordinary fluctuations encountered. However, while it has been found that the maximum required for holding engines is at the rate of 30 B.H.P. for each engine on the line, actual experiments show that if the stationary boiler pressure can be maintained at fairly uniform rate, the hourly consumption per locomotive will average about 10 B.H.P. per hour.

With an average stationary boiler plant coal consumption of 4½ lbs. coal per boiler horsepower hour, the fuel required to hold a locomotive under steam in the enginehouse by the direct steaming system is about 45 lbs. coal per hour. A further economy is possible where a cheaper grade of coal can be utilized in the stationary boilers than required for locomotive use. The use of stack blowers in the enginehouse represents a steam consumption variously estimated at from 40 to 80 boiler horse power per hour. With the direct steaming system the enginehouse blower is entirely eliminated except for occasionally cooling down the boiler when necessary for a man to work in the firebox.

Steam Consumption Test

Filling and Steaming Locomotive 5039, Battle Creek, Dec. 3, 1926

Time	Pressure Steam at Booster	Locomotive Gauge Pressure	Steam Flow Lb.-Per Hr.
11:40 A. M.	115	0	5250

Start to fill locomotive with water at temperature of 180 deg. and steam from boiler plant.

Time	Pressure Steam at Booster	Locomotive Gauge Pressure	Steam Flow Lb.-Per Hr.
11:55 A. M.	115	10	6000
12:04 P. M.	105	25	5500

Close water line valve, one gauge water in boiler.

Time	Pressure Steam at Booster	Locomotive Gauge Pressure	Steam Flow Lb.-Per Hr.
12:30 P. M.	115	62	5500
12:45 "	117	80	5000
1:00 "	125	95	3750
1:20 "	125	120	3000
1:45 "	135	130	1500

Booster steam valve closed to ⅛ turn.

STEAM CONSUMPTION TEST

Holding Steam Pressure on Locomotive 5039, Battle Creek, Dec. 4, 1926

Time	Boiler Plant Pressure	Locomotive Gauge Pressure	Water Glass Reading in Inches
8:30 A. M.	136	137	5¼
9:30 "	135	135	6
9:45 "	140	132	6
10:00 "	125	127	5¾
10:15 "	135	130	6

Booster steam valve closed to ⅛ turn.

Time	Boiler Plant Pressure	Locomotive Gauge Pressure	Water Glass Reading in Inches
10:30 A. M.	145	132	6¼
10:45 "	135	131	6¼
11:00 "	140	132	6½
11:15 "	140	133	6¾
11:40 "	140	134	7

Note: Rise of water from 5¼ inches to 7 inches above crown sheet in locomotive 5039 represents condensation of steam delivered to locomotive boiler at rate of 189.4 lb. per hour.

Locomotive Feed Water Heaters

The following table shows the number of heaters installed or on order as of May 1st for each year since 1920:

	Exhaust Steam Pump Type	Feed Water Heaters Injector Type
1920	7	...
1921	54	...
1922	234	...
1923	1429	...
1924	2123	24
1925	2551	37
1926	2527	362

We are indebted to Mr. A. G. Hoppe, of the Committee, for the following treatment of a subject bearing closely upon the value of feed water heaters as determined from experience on the road with which he is connected.

One of the purely incidental but none the less important features of the open type feed water heater, is its vent to atmosphere through which oxygen carrying gases, nearly always present in boiler feed waters, find their escape. In studying the underlying factors whereby to account for the corrosion of boiler tubes and sheets, research chemists have arrived at almost universal agreement in support of the theory that much of the pitting and corrosion within the boiler structure is akin to, if it does not actually partake of the nature of, electrolytic or galvanic action. They are in agreement, furthermore, that the extent of this pitting is directly proportioned to the degree of hydrogen-ion concentration within the boiler, which concentration in turn, is governed by the presence or absence of oxygen in some one or more of the several forms in which it is found in boiler water supply.

Since the foregoing accounts for a conspicuous share of the pitting difficulty, it follows that a reduction in the amount of oxygen, of whatever form, present in boiler feed water, will serve to reduce in some degree the sum total of trouble which can be accounted for as above. Laboratory tests of the open type feed water heater show that, in the process of heating the boiler feed water up to normal temperatures for this type of apparatus, say 220 deg., as much as 85 to 90 per cent of the oxygen carrying gases are vented to atmosphere and prevented from entering the boiler. An attempt to check this result in road trials, indicated that as high as 80 per cent of these gases can be and are eliminated in regular road service.

It has been sought to check the extent of the improvement possible in the life of boiler tubes through the use of the open type heater, by means of an installation on a freight locomotive in the upper Missouri Valley, where very bad pitting conditions ordinarily prevail. This installation has been in service for the past 18 months and while, as was to be expected, it has not served totally to nullify the pitting and corrosion trouble, it has been found so far to inhibit the process as to prove beyond a reasonable doubt that some worth while measure of benefit is to be derived in this manner.

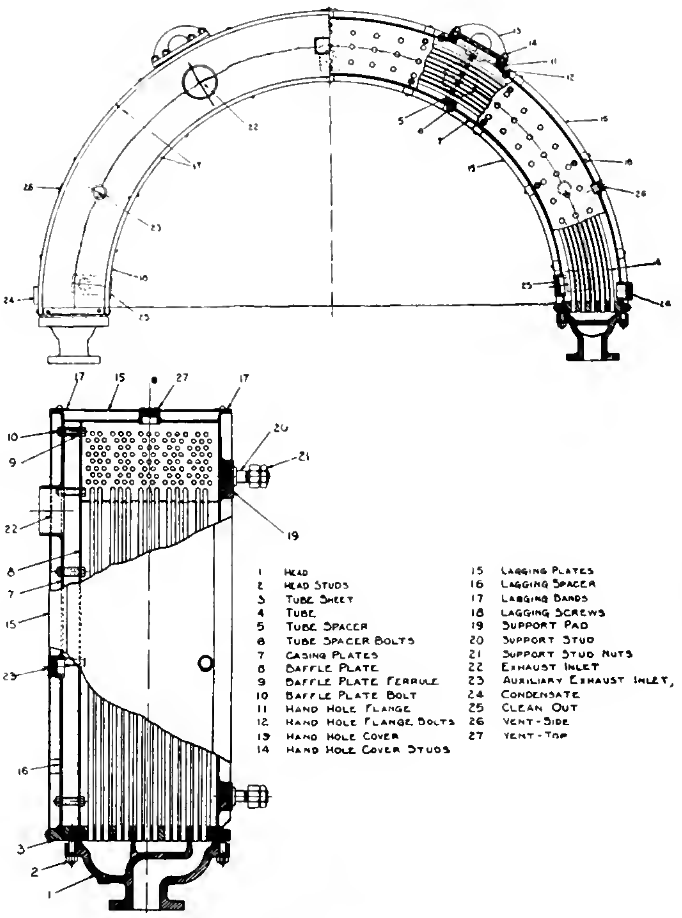
The problem of pitting and corrosion is far too complicated to be acounted for in toto as per the foregoing. Its abatement in locomotive service, even where deaeration is to be recognized as a useful agent, is further complicated by the fact that certain quantities of water must be fed to the boiler, as when the locomotive is not exhausting steam, or when for whatever reason, it is fed by means of the injector, when there is lacking the opportunity to extract the corrosion accelerating gases. Manufacturers of the open type heater have devised apparatus designed to take into the heater at will, when the engine is not working, either auxiliary exhaust steam or live steam at reduced pressure, or both, as a means of maintaining feed water temperatures under conditions of standing or drifting and of degasifying in some greater or less degree the water being fed into the boiler under conditions as stated.

It is to be understood, of course, that the aforementioned feature of the open type heater is purely incidental to its primary function as a waste heat retriever, a fuel economizer, and a capacity increaser. It is further to be understood that there are certain types of pitting that cannot be inhibited to any great extent through the process of deaeration. On the other hand, since this type of heater has been proven to be able to take out 75 to 80 per cent of these objectionable gases under conditions of every day service, it must be acknowledged to be a benefit in some degree proportional to the extent of the deaeration effected and to the extent that the gases present in the water can be held accountable for the phenomenon of boiler corrosion.

Where the amount of encrusting matter carried into the boiler with the feed water is not so great as to preclude its use, the top boiler check in combination with a device of whatever nature that will serve to inject the water into the steam space in a finely divided state, offers further opportunity for the escape of these gases into the steam and with the steam out through the throttle and cylinders, with greatly diminished opportunity for such gases to accelerate the pitting and corrosion process. Such being the case, the open type feed water heater in conjunction with the top boiler check should give almost total immunity from pitting troubles under those conditions of service where such troubles can be traced to the presence of oxygen or other gas content in the boiler feed water.

New Closed Type Heater

A new feed water heater of the closed type as shown in the accompanying illustration has recently been placed on the market. It is semicircular in shape, and has a rectangular cross-section. The tubes are bent to conform to the shape of the body and are rolled into the tube sheets.



New Closed Type Feedwater Heater

No provision is made in the joint in the sheet for expansion or contraction, this being taken care of by the bent tube construction. The water is passed through the tubes, the heads being so arranged that the water makes five passes through the heater. The exhaust steam enters the front of the heater and is distributed over the tubes by a perforated baffle. The main heater is mounted on the front of the smoke arch, either on the front end plate, or recessed into the top of the smoke arch so that the front of the heater and the front end plate are flush.

This type of heater makes use of a small centrifugal pump driven by a single stage steam turbine. The small centrifugal pump is usually mounted under the left front corner of the firebox. Its speed and hence the rate of feeding the boiler is controlled from the cab through a special valve. To prevent injury to the pump due to overspeeding, a safety trip is provided which shuts off the steam, in the event of trouble of this nature. The usual tank strainer is supplemented by a special strainer at the pump to exclude foreign matter. The only parts of the pump subject to mechanical wear are the ball bearings, of which there are two. The following tables show the water rate of this pump in per cent of water pumped, as given by the manufacturer, but does not indicate whether the results were obtained with superheated or saturated nor the pressure against which the pump was operating at the time these tests were made.

Gallons Pumped Per Hour	Steam Req'd by Turbine Percent of Water Pumper
4800	2.40
5400	2.10
6000	1.97
6600	1.86
7200	1.77
7800	1.69
8400	1.63
9000	1.58
9600	1.57

In addition to the pump and the main heater, this system makes use of an auxiliary heater located in the tank, immediately behind the pump suction. The condensate from the main heater and the stoker exhaust are led into this device and are discharged so as to mingle with the water being taken by the pump. A vent is applied to remove any uncondensed vapors or air. The auxiliary heater thus acts both as heater and as a trap for the removal of vapor and air.

In the operation of this equipment either superheated or saturated steam is supplied to the pump through the special control valve located in the cab by means of which the boiler feed is regulated. The exhaust from the feed pump is conducted to the cylinder saddle and cut through the stack. A compound steam gauge in the cab shows the water discharge and pump steam pressures. Water is taken from the tank on the left hand side in the usual manner, the pump suction being preheated by the condensate and smoker exhaust as previously mentioned. The suction line on the engine is vented to the atmosphere to prevent accumulation of air and steam.

Exhaust steam is taken from the exhaust cavities of the cylinders on each side and enters the heater through a manifold on the front of the heater. The air pump exhaust is also discharged into the heater through this manifold. The heater operates on the counterflow principle, that is, the steam first strikes the tubes containing the last pass of the water and finally passes around those containing the first pass, this method providing the maximum possible difference in temperature at all times. The condensate is led back to the tank and with the stoker exhaust is discharged into the auxiliary heater as previously mentioned.

Heating Feed Water in Tenders

A number of railroads are obtaining a small saving by reclaiming the heat in the air pump and stoker engine exhaust by passing it into the water in the tender. To prevent overheating the water, some form of thermometer is provided and when the maximum temperature desired is reached, the exhaust is turned into the stack. The equipment required can be applied to an engine without very great cost and with very little subsequent maintenance.

The method used by the Union Pacific where engines are equipped with inspirators is as follows:

An exhaust pipe is run from the air pump and stoker into the tank, entering through the bottom, extending vertically to a point about 12 inches above the highest water line in the tank, back to the rear of the tank to within about 8 inches of the back wall, and then vertically down to within about 8 inches of the bottom. The lower end of the pipe is open and the steam is discharged directly into the water. A check valve is located in the highest point of the pipe. To afford a guide as to the temperature of the water in order to prevent overheating, some sort of thermometer should be provided. The ordinary Moto-meter, equipped with an extra long stem so that the bulb is within 6 inches of the bottom of the tank makes a very satisfactory installation. . To protect the Moto-meter from surges of the water it is encased in a ¾ inch pipe which in turn is welded to the top of the tank and well braced. To insure contact of the thermometer with the water, the case mentioned should be perforated with small holes.

A three-way valve is provided in the exhaust line mentioned to enable the fireman to turn the exhaust either into the tank or into the cylinder saddle as desired, a 2 inch valve being recommended for this purpose. The plug of the valve is drilled with a ⅛ inch hole so as to allow a small amount of steam to pass through the exhaust pipe to the saddle to prevent freezing in cold weather. In applying the exhaust piping, right angle bends should be avoided as much as possible. The air pump working under the conditions mentioned is not unduly restricted and meets all tests and requirements of the Federal Law. Some experiments are being made in which this three-way valve is dispensed with and a globe valve placed in the exhaust line of the air pump to the cylinder saddle. Where it is desired to turn the exhaust into the stack this valve is opened and is closed when it is desired to heat the water.

In cylindrical tanks the space under the splash plate can be reduced and that plate utilized as a baffle. A heater chamber will in effect be formed and a smaller amount of water will be heated to the desired temperature more quickly.

Tanks equipped for preheating the water should be plainly stenciled, calling to the attention of the fireman, that the Moto-meter or thermometer should not be allowed to register over 120 degrees in order to avoid trouble with the inspirators. On small power with corresponding smaller inspirators this maximum temperature should be reduced to 110 degrees.

The temperature of 110 and 120 degrees referred to, are of course, the temperature to which the water is preheated in the tank and not the temperature of the water at which it enters the boiler. The following table indicates the temperatures of the water in the tank and the temperatures at the boiler check for different conditions of operation of the inspirators.

Temperature of Water at Boiler Check Delivered into Boiler with Inspirator

Water in Tank Preheated to	Inspirator Wide Open	Inspirator Half Open	Inspirator at Minimum
110 degrees	225 degrees	235 degrees	275 degrees
120 degrees	235 degrees	240 degrees	295 degrees
130 degrees	245 degrees	250 degrees	305 degrees

Temperature of water in tender 55 degrees.

The Boston and Maine Railroad is making application of a somewhat more elaborate nature in connection with non-lifting injectors. A section of the tender tank is partitioned off, forming a hot water chamber, and the exhaust steam from the auxiliaries is discharged into this section through a 3 inch pipe carried back for that purpose.

A thermostatically-controlled, air operated valve is installed in the exhaust steam pipe and when the water in the heating chamber reaches the desired temperature, this valve is closed and the exhaust from the auxiliaries goes to the saddle in the usual way. The thermostatic control is set at a temperature which permits the injector to operate satisfactorily. There is a valve of the flapper type installed at the botom of the partition between the heating chamber and the remainder of the tender tank, which lets cold water flow into this chamber as the hot water is removed for boiler feeding.

Experience has shown that the injectors on the class of engine now equipped, which carry 180 lb. boiler pressure, will operate satisfactorily with the water at a temperature of about 107 degrees. With an average water temperature of 60 degrees in the main part of the tender, a temperature rise of 47 degrees is obtained with this equipment.

With only two 9½ inch Westinghouse air compressors discharging into the heater line, it has been found that the heating chamber would have a capacity of about 1,500 gallons to allow an average of 107 degrees to be attained. The size of the heating compartment will vary with the amount of exhaust steam discharged into it and the evaporation of the boiler. It is expected that the size of this compartment will be adjusted to conform to the requirements of the particular conditions and any class of locomotive in a particular service.

When using two 9½ inch air compressors, the exhausts are brought together into a 2 inch pipe and immediately beyond the connection there is a tee, having 3 inch side outlet, which is continued back to the tender with a metal hose between engine and tender. Directly beyond the 3 inch tee there is a 6 inch nipple of 1½ inch pipe. This line is then enlarged to 2 inch and carried to the usual connection in the cylinder saddle. This short nipple of reduced size forms sufficient restriction to force the required amount of steam back through the 3 inch pipe into the heating chamber of the tender. When the water in the heating chamber reaches the desired temperature, the 3 inch line is closed off and the pumps operate against a somewhat increased back pressure as they exhaust into the saddle.

The connection between the engine and tender is formed by a 3 inch flexible metal hose having an automatic ⅛ inch drain at the lowest point. An emergency hand-operated valve has been installed in the steam line, with an extension handle in the cab, which will permit this connection to be closed off, if through accident, the water becomes too hot to be handled by the injector.

Immediately back of the hose connection on the tender a diaphragm valve is installed in steam pipe. This valve is operated by air pressure. Beyond it the pipe is carried up through the bottom of the tender to a point well above the water level and then returns again into the heating chamber and discharges through two silent heaters placed near the bottom of the compartment. A ¼ inch ball check valve has been applied at the highest point which will permit the entrance of air and break any vacuum that might be formed in the pipe. This is provided to prevent the water's being siphoned back through this connection and into the cylinders of the pumps or into the saddle of the locomotive.

A connection is made from the train line on the tender through a separator and a reducig valve to a Power's temperature regulator installed in the heating chamber at a point 2 inches from the bottom. This regular or thermostat controls the admission of air to the diaphragm valve in the steam line and will close it when the water in the heating chamber reaches the temperature for which it is set and open it in turn when the water falls below this temperature. Failure of air pressure automatically closes diaphragm valve in steam line and prevents possible overheating of water.

Gauges are installed on the tender to show the action of the thermostatic regulator and a gauge in the cab shows the exhaust steam pressure in the 3 inch line.

As a precautionary measure, the suction to one injector is connected behind the tank partition so that cold water is available for boiler feeding in case of heating beyond the ability of the injector to lift it.

A number of test runs have been made with this equipment and in May, 1926, two runs showed the following results:

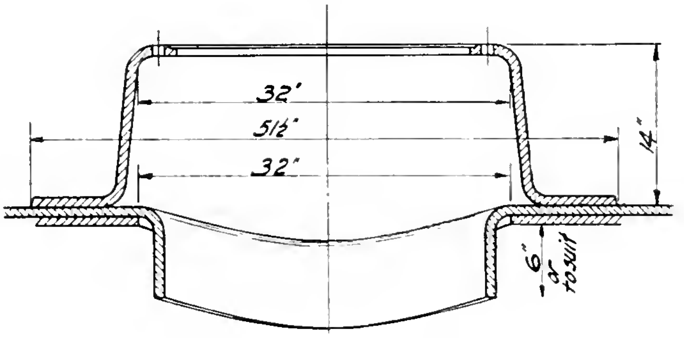
	Run No 1	Run No. 2
Tank Water Temperature	49½ deg.	47 deg.
Temperature of Atmosphere	61 deg.	65 deg.
Temperature of Suction Water	*118.4 deg.	107.7 deg.
Boiler Pressure Average	179 lb.	172.6 lb.
Back Pressure on Pump	3.6 lb.	4 lb.
Average Water used per hour	16,740 lb.	15,160 lb.

**Temperature considered too high for positive operation of lifting injector.*

Heating the water in the tank results in a saving of from 3 to 4 per cent of the fuel used by the locomotive. While this is small, yet the investment required is small, and the subsequent cost of maintenance is also small. The saving undoubtedly justifies the cost of application and maintenance.

Locomotive Steam Desaturators

The use of steam desaturators, for which there is some precedent in stationary boiler practice, appears to offer a yet undeveloped field for further improvement in locomotive performance. Furthermore, the trend toward larger locomotive boilers and increased boiler capacity is increasing rather than diminishing the need for practical means to prevent carrying a high percentage of moisture over with the steam to the superheater units and even into the locomotive cylinders.



Method of Down-Flanging Dome Hole to Prevent Surging of Water in Steam Dome

The effect of moisture in steam carried to the superheater units is not only an immediate reduction in the superheat temperature, but a gradual scaling of the interior of the superheater tubes causing a cumulative reduction in the superheat between shopings. The effect of water carried into the cylinders is too well known to require description here.

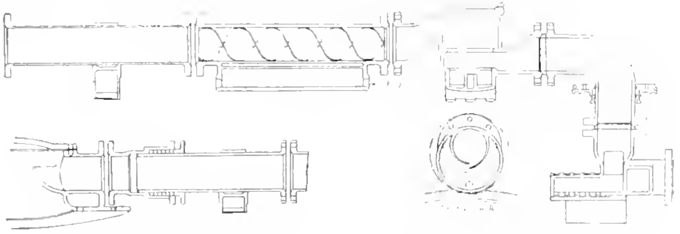
Clearance limitations affecting modern locomotive design make it difficult to provide sufficient steam space between the surface of the water and the inlet to the dry pipe, but consideration of this feature in boiler design may effect considerable improvement in the quality of steam. In a recent new locomotive design of the Mountain type the tendency to carry over considerable quantities of water with the steam was in a measure corrected by the construction of an elliptical course in the boiler shell which gave increased height to the boiler shell over the water level at the point of steam intake.

Another practical expedient for reducing the quantity of water carried into the dry pipe is found in flanging the edges of the dome hole downward so as to form a screen to prevent water from surging or splashing up into the steam dome, although neither of the means above described could be regarded as equivalent to a desaturator as applied in stationary practice where much more exacting standards are applied to the quality of steam delivered by modern boilers operating at high overload capacities.

The introduction of baffling devices or other means for precipitating moisture from the steam as it is drawn from the steam space to the superheater units presents a difficult problem in locomotive construction aside from additional weight and expense of such apparatus for the reason that unless an outside dry pipe is used, the desaturator must be positioned inside of the boiler. This is objectionable unless the device is readily accessible for inspection and maintenance.

In this connection, the attention of your committee has been called to the advantages of an outside dry pipe arrangement as recently installed by the Kansas City Southern R. R. on some large Mallet type locomotives. This is not only adapted to the installation of a desaturator in the dry pipe outside the boiler as illustrated in an accompanying drawing, but is claimed to effect an obvious reduction in locomotive maintenance through elimination of the joint between the dry pipe and front flue sheet.

The desaturator employed with the outside dry pipe is constructed in the nature of a spiral which causes the steam to whirl rapidly as it is drawn through the desaturator. This has a tendency to throw all moisture particles to the outer wall of the desaturator where this water is caught by a groove, collected and returned to the boiler. In the design and application of this desaturator considerable attention was given to such detail features as the joint between the condensate return pipe and the boiler. The outside steam pipe and the desaturator require thorough lagging to prevent additional condensation, but as installed, this device is rapidly accessible to inspection and can be easily removed and replaced without adding materially to the weight of the locomotive.



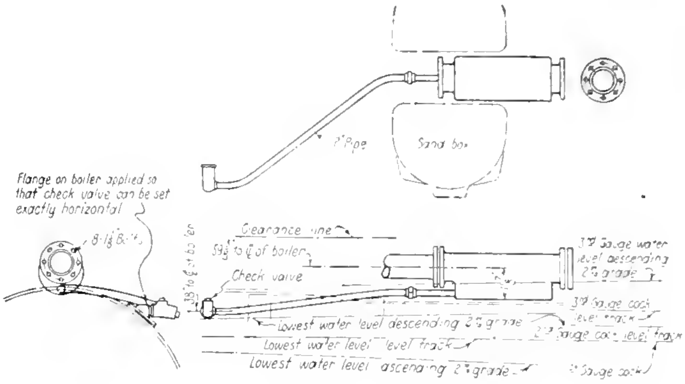
Outside Dry Pipe with Spiral Steam Desaturator

No tests of the desaturator have been made to determine the actual reduction effected in moisture content of the steam, but it has been ascertained that there is no appreciable pressure drop in the steam flowing through this device and it is understood that some additional locomotives of the same type on this road are being equipped with the outside dry pipes and spiral desaturators as these locomtives go through the shops.

Another development known as the Centrifix desaturator which has recently found quite wide use in stationary steam practice has recently been applied to locomotive for test on several railroads. This type of desaturator requires no important change in the construction of the locomotive, but can be installed in a steam dome of the conventional, by means of a pan which fits into the steam dome and inserting a number of Centrifix units in this plate. The arrangement is supplemented by a cylindrical apron supported from the dome opening in the boiler and suspended from this point down to within 3 inches of the top of the flues as shown in the accompanying illustrations.

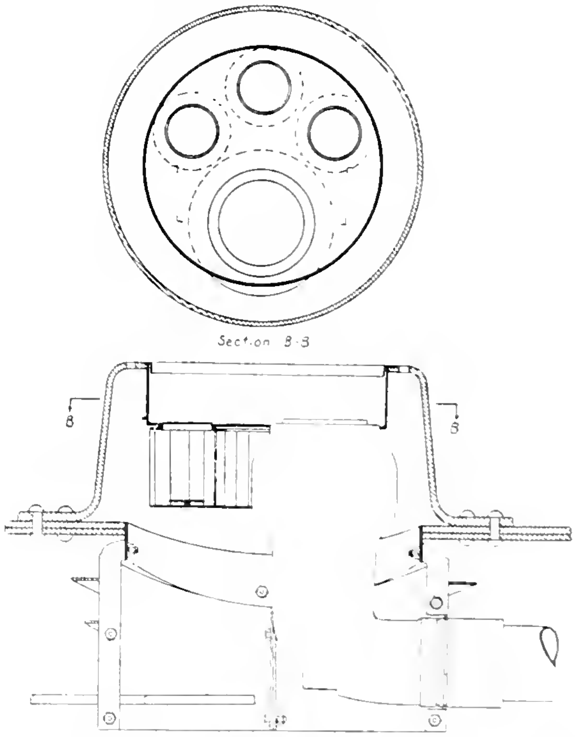
The Centrifix Unit itself, as shown in the illustration, comprises a series of oblique blades that impart a violent whirling motion to steam drawn horizontally into the unit. This throws the moisture against the edges of these blades from which it is precipitated. The effect of the cylindrical apron is to create a steam pool below the centrifix units and prevent surge of water in close proximity to the centrifix and consequent overloading of the units. Separate openings for the dry pipes to the auxiliary turrets are cut in the plate supporting the centrifix units so that all steam drawn from above this plate is subject to this desaturating effect. The capacity of this device can be augmented by inserting additional centrifix units of the same size in the plate or by using standard units of larger dimensions. All of these units are constructed with Monel metal blades. The units themselves are bolted to the plate as shown.

Test of the centrifix type of desaturator recently conducted by one railroad on a Pacific type locomotive improved the steam quality from 98.7 per cent without the desaturator to 99.6 per cent with the desaturator. This increase in quality of the steam was noticeable to the extent of about 10 degrees increase in superheat temperature.



Arrangement of Spiral Type Desaturator Inserted In Dry Pipe and Return Drain

Furthermore, it was found that in throwing out the water from the steam, all impurities were kept from the cylinders and the inside of the centrifix pan was clean while the outside had accumulated quite a scale deposit. This clearly indicates that in addition to the direct effect of removing moisture from the steam and consequently improving the superheat, the desaturator lessens the pro-



Centrifugal Steam Desaturating Units in Locomotive Steam Dome with Circular Pan to Prevent Overloading Desaturator gressive accumulation of scale in the superheater units and thus, in time, exerts a considerably greater influence upon superheat than reflected in an immediate comparison of temperatures as above given.

The advantage of the desaturator from this standpoint is naturally enhanced in bad water districts, where the tendency to carry over water with the steam is greater and where a larger amount of scale forming impurities are entrained with the steam. Under these conditions, the desaturator not only reduces formation of scale in superheater, but may serve to prevent moisture being carried into the cylinders where it retards lubrication and may even damage the engine.

The value of any effective desaturating device should not therefore be gauged by its immediate effect upon fuel consumption, but rather by its culmulative effect upon the performance of the locomotive and in this connection, consideration should be given to the fact that such types of this desaturator as are already available add little to the weight of a locomotive and do not appreciably affect its maintenance cost, since the device is in the nature of a permanent fixture without moving parts.

Mechanical Cut-Off Control

There are now over a hundred engines equipped with mechanical cut-off control. An additional feature has been added to this device, it being now possible to operate the locomotive at any one of three different exhaust pressures by manual adjustment of a valve in the cab, a development of added operating merit to the device as originally put in service. With the advent of this three-pressure setting attachment for the cut-off control there has been eliminated all the parts heretofore in the cab, namely, the foot valve, primary control valve, gauge, panel and valves. There is now only one valve in the cab which the engineer may adjust manually for any one of the three pressure settings. This feature allows the engineer to set the device so that the locomotive may operate to 100 per cent of its capacity, again at 75 per cent and again at 25 per cent and the cut-off will be adjusted without his further attention. The device may also be set to any other percents than 75 and 25 that operating conditions require.

Back Pressure Indicator and Gauges

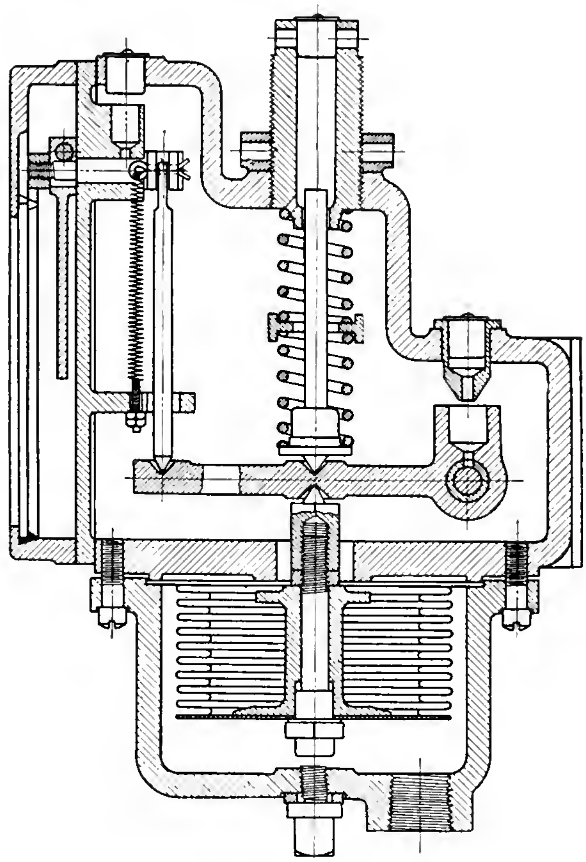
For the manual control of cut-off, the cut-off indicator has been designed and put in service, the purpose of this device being to tell the engineer in what direction he should move his reverse lever in order to maintain that back pressure for which the indicator is set. In this way, the engineer has a direct indication of back pressure as an index to him in the proper adjustment of his reverse lever.

The device is designed to give a large movement of the hand for slight variations in back pressure, much greater than is obtained on the gauge, is easily visible and employs a construction that is more staple than that employed in gauges.

The device is again designed particularly for the mechanical strength, durability and accuracy in locomotive service for this specific purpose. It is designed with the full appreciation of the fact that if cut-off is to be regulated to back pressure, it must be regulated accurately and the engineer must be furnished a true, accurate indication of pressure.

This cut-off indicator serves a double purpose of a back pressure gauge and a throttle pressure gauge, eliminating the necessity for a separate pipe from the steam pipe back to the cab and a gauge or a hand of a duplex gauge for indicating throttle pressures. This is made possible by virtue of the fact that throttle opening and the steam pipe pressure is directly discernible as back pressure.

Referring to the cut-off indicating guage, of the Indicator, if the pointer is over the position "DOWN," this would indicate to the engineman that he should hook his lever down. If any opening of the throttle will cause the pointer to move to the position "HOLD," it immediately indicates that the throttle was not open sufficiently for that cut-off and the throttle would then be opened instead of the cut-off being lengthened, which is much more economical.



Back Pressure Indicator for Locomotives

There are several back pressure gauges on the market and there is at least one railroad that now has the most of their locomotives equipped with the ordinary back pressure gauge.

Air Whistles for Locomotives

About two years ago, Dr. A. L. Foley of Indiana University, was quoted as follows: "Railroad locomotive whistles use four tons of water and 1,200 pounds of coal for every hour of continuous operation."

This statement caused widespread comment and no little criticism, but subsequent investigation by the railways has disclosed the fact that in the aggregate, locomotive steam whistles are indirectly responsible for the consumption of a large quantity of locomotive fuel.

The increasing use of motor rail cars in local passenger service has led to development of air operated whistles of sufficient calibre for steam railway requirements and several roads have more recently been experimenting with the use of this type of whistle on locomotives in place of the customary steam whistle.

A recent test on the Union Pacific Railroad as reported to this Committee indicates that there is a fuel saving from the use of air whistles in place of steam whistles of about $1.15 per locomotive per day in passenger service between Omaha and Cheyenne. On this road it is the practice to whistle for the operator's signal at each station and acknowledge the clear signal, but on the other hand, the grade crossings for which the crossing signal must be blown are less frequent on this line than in other sections of the country where the fuel saving resulting from the use of air whistle would consequently be greater.

The Union Pacific Railroad further reports that numerous favorable reports have been received from Chambers of Commerce, automobile drivers, business men and others regarding the agreeable tone and penetrating characteristics of this type of locomotive whistle.

Controlled Draft in Locomotives

The matter of controlled draft to meet steam requirements has been the subject of intensive study on the part of combustion engineers ever since the first locomotive was placed in service. Attempts ranging from adjustable nozzle tips to various forms of exhaust fans have been tried, found wanting and discarded.

While with the present form of draft producing appliances, i.e., combination of exhaust nozzle, stack, etc., the draft is practically automatic, and changed to conform to steam requirements, yet at the higher ranges of evaporation it has always been at the expense of cylinder horsepower as expressed in back pressure.

About one year ago the general principles underlying forced draft as in use in stationary practice were experimentally applied under the direction of Mr. E. C. Fogh, special Engineer to Texas & Pacific Locomotive No. 524, a 2-10-2 type with the following general characteristics:

Cylinders—28 x 32 inch.
Tractive force—69,400 pounds.
Grate Area—76.3 square feet.
Steam pressure—200 pounds.
Evaporative Heating Surface—4,666 square feet.
Superheating surface—1,085 square feet.

Due to the immense deposits of lignite coal in the State of Texas and the economies possible to be effected through the use thereof, it was decided to make the initial tests with lignite having the following proximate analysis:

Sulphur	.59%
Volatile Matter	31.45
Fixed Carbon	27.38
Ash	11.87
Moisture	29.30

B. T. U. Content, as fired—7,230.

The apparatus consists of a Coppus turbine driven fan of 34,000 cubic feet capacity at 7 inches pressure. The fan is located under the left running board as illustrated in the accompanying drawing.

The grates are of the Rosebud type such as developed on the Northern Pacific, having one-half inch round openings with a total of 13 per cent to grate area. Top or supplementary air is supplied through a duct connected to a fire door of special design, as shown in the accompanying photograph.

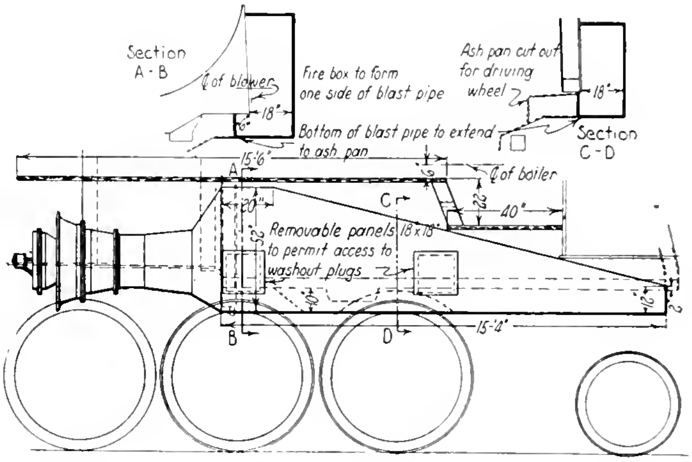
Realizing that some benefit could be obtained in the way of front end draft through the use of the exhaust steam, but also having in mind that owing to the low velocity of the escaping gases ample stack outlet was necessary, the stack was enlarged to the equivalent of 25 per cent over the tube area, or to 39 inches, and in order to fill a stack of this diameter a special nozzle was designed having a 9-inch clear discharge orifice, but below this orifice a helix contained in a 10-inch pipe.

As of course, there is a constant pressure in the firebox so long as the fan is in operation, it follows that the locomotive must be stoker fired, and for this purpose the duPont-Simplex Type B Stoker was selected.

With controlled draft the locomotive must of necessity be 100 per cent stoker fired, as the fire door cannot be opened. Furthermore, the distribution must be absolutely perfect, as any slight thickening of the fire at any point would immediately result in a bank through which the air from beneath could not be forced, and therefore, owing to the characteristics of lignite coal, combustion would cease over the entire area covered by the bank. Therefore, as stated above, the distribution must be absolutely perfect, and the fire maintained at an even thickness of about 1½ to 2 inches on the grates.

An opening 6 inches in diameter, covered with a mica shield, is provided in the backhead, and another 4 inches in diameter in the center of the fire door, through which the condition of the fire can at all times be observed and the distribution of coal adjusted accordingly.

The locomotive with this apparatus has been in constant freight service since July, 1925, during which period it was often necessary to double the load. Steam pressure has been maintained, while not always at the maximum, yet sufficient to handle all trains offered without delay.



Arrangement of Turbine Fan for Air Duct for Controlled Draft

While no comparative tests have been run as yet, observation indicates conclusively a marked reduction in fuel as compared with the consumption when the locomotive was equipped in accordance with universal standard practice, i.e., depending on the exhaust only for draft. The major saving consists in a gain of approximately 400 cylinder horse-power due to the practical elimination of back pressure. This gain in horse-power, translated into tonnage, means the equivalent of a 10 per cent increase both in tonnage and speed.

There is practically no stack loss, a very desirable feature in the territory (cotton fields), in which the locomotive is in operation. This is the more remarkable when we consider the character of the coal burned.

These experiments with controlled draft have not yet been completed and the results thus far obtained are not sufficiently definite to justify the Committee in drawing any broad conclusions as to the immediate possibilities of this development.

If controlled draft can be adapted to meet the every-day operating requirements of locomotives in regular service it will eliminate the losses now occasioned by cylinder back pressure and facilitate the development of the high steam pressure turbine locomotive where all of the exhaust steam is condensed.

Compared with previous developments along this line, controlled draft has the advantage over induced draft, of forcing a relatively smaller volume of cool air through the fan instead of drawing the hot gases of combustion through a fan in the front end. Controlled draft also has a fundamental advantage over induced draft from a combustion standpoint, as pointed out in the foregoing.

Committee Report on Diesel Locomotives

This Committee finds that there has been considerable development work on the Diesel Locomotive during the last year. However, the greater portion of this development work has been done by the locomotive builders, who are not ready to report in full detail on the progress they have made.

The Baldwin Locomotive Works are building a second experimental 1000 h. p. locomotive. This locomotive will use a Krupp 6 cylinder 4 cycle Diesel engine. The first experimental 1000 h. p. oil engine driven locomotive built by this company used a 2 cycle engine and is being subjected to exhaustive tests before being placed in regular service.

The Ingersoll-Rand, General Electric and the American Locomotive companies are building an oil engine driven locomotive with a 6 cylinder, 4 cycle engine rated at 750 h. p. at 500 r. p. m.

The McIntosh & Seymour, American Locomotive and General Electric companies are building an oil engine driven locomotive with a 12 cylinder, 4 cycle engine rated at 960 h. p. at 325 r. p. m.

One railroad company has designed a new type of Diesel locomotive and is now building three of these locomotives in its own shop.

All of the Diesel locomotives in service in this country at the present time and all of this type of locomotives now on order from builders in this country use electric transmission. The apparent tendency in foreign countries is to use some type of transmission other than the electric. The transmissions which are being developed in foreign countries are—hydraulic, geared, with magnetic clutches and the compressed air types. Detailed descriptions of these transmissions and the locomotives which use them have been printed in the technical press.

Foreign Diesel Locomotives

The 1200 h. p. Diesel locomotive with air transmission built by the locomotive firm Maschinenfabrik Esslingen, has been completed and we understand is at present undergoing tests on German State Railways.

The 1000 h. p. Diesel locomotive with gear transmission built by the Hohenzollern Company at Dusseldorf, Germany, for Russia, was tested on a testing plant at Dusseldorf and on German roads, and sent to Russia under its own power. Last March it was demonstrated in Riga, Latvia, and crossed the Russian border.

It will be recalled that the gear transmission consists of shafts with gears always in mesh and has three speed friction clutches operated magnetically and a main magnetic friction clutch between the oil engine and the gear. The three speeds are 9, 17 and 30 m. p. h. The tests on the testing plant showed that the rail tractive efforts at these speeds are correspondingly 39,000, 20,000 and 11,000 lbs., and that the transmission efficiency was approximately 90 per cent. Slightly increased tractive efforts can be obtained by overloading the oil engine, and variation in speed within certain ranges can be obtained by changing the number of revolutions of the oil engine.

The tests showed that the consumption of fuel at full power amounted to only .49 lbs. of oil per rail horsepower-hour, this corresponding to 29 per cent oveall thermal efficiency of the locomotive. The efficiency of the 1000 h. p. Russian Diesel locomotive with electric transmission, it will be recalled, was about 24 per cent.

However, at lower load factors the efficiency of the geared transmission type locomotive does not seem to be so high; for instance, at 50 per cent load factor the efficiency amounted to only 19 per cent and at 33 per cent load factor—to 12.5 per cent, this resulting from the lower efficiency of the Diesel engine itself at low load factors.

During the road tests the maximum drawbar pull at starting a 1320-ton train on a 1.1 per cent grade was recorded to be over 44,000 lbs. The manipulation did not seem to be too complicated, the only disadvantage being the discontinuity of tractive effort and horsepower and their drop to zero at the time of changing speed.

As a result of the tests, it was decided to increase the number of speeds for future orders from 3 to 4, making the first speed approximately 6 m. p. h. The auxiliary Diesel engine has been abandoned and the drive to auxiliaries is now being obtained directly from the main Diesel engine.

Nydquist and Hohn, Trollhattan, Sweden, have built one 300 h. p. Diesel hydraulic drive locomotive for the Uddevalla-Vanersborg Railway, but there are no operating figures for publication.

One 300 h. p. Diesel-Oil-Electric locomotive built some years ago at D. E. V. A., Vasteras, Sweden, is now in regular service between Uppsala and Enkoping, about 28 miles, with the twelve station stops. Weight of train, 102 tons.

Fuel oil used is	1.2375 lbs. per train mile
Lubricating oil used is	.0015 lb. per train mile

One 160-200 h.p. Diesel-Oil-Electric locomotive, type 1-A-A-D built by the same firm, has been in service since 1924 on the Skane-Smaland Railway, weight of locomotive, 38 tons. The 8 cylinder Diesel-motor makes 500 r. p. m., and the locomotive is operated over a railroad having grades up to 1.67 per cent. The Diesel motor drives one generator furnishing direct current to two 65 h. p. motors, each directly connected to one of the two driving axles.

During 1926 it has operated..............	166,564 miles
Weight of train	88 to 100 tons
Fuel oil used	.00075 lb. per ton mile
Diesel lubricating oil used	.00068 lb. per ton mile
Engine oil used	.00055 lb. per ton mile
During 1926 it has been in for general repairs ..	54 days
During 1926 it has been out of service for running repairs	17 days
During 1926 it has been out of service account too light to handle heavy train	1 day
During 1926 it has been in service	293 days

Mr. Rosen, a Swedish Engineer, is still experimenting with his hydraulic transmision on the 300 h. p. locomotive that was built in 1925, and which is still in regular service.

The following is a list of the names of companies in this country who are now operating or have on order Diesel-Oil-Electric locomotives.

Name of Operating Company	No.	Wt.	Horse Power	Delivered
Central R.R. of New Jersey	1	60 ton	300	October, 1925
Long Island R.R.	1	100 "	600	December, 1925
Baltimore & Ohio R.R.	1	60 "	300	December, 1925
Lehigh Valley R.R.	1	60 "	300	January, 1926
Chicago & North Western Ry.	1	60 "	300	April, 1926
Erie	1	60 "	300	May, 1926
Delaware, Lackawanna & Western R.R.	1	60 "	300	June, 1926
Reading	1	60 "	300	June, 1926
Delaware, Lackawanna & Western R.R.	1	60 "	300	July, 1926
Utah Copper Co.	1	60 "	300	August, 1926

Red River Lumber Co.	1	100	"	600	September, 1926
Great Northern Railway	1	100	"	600	October, 1926
Chicago & North Western Ry	1	60	"	300	October, 1926
Ingersoll-Rand Co.	1	60	"	300	November, 1926
Chicago & North Western Ry.	1	60	"	300	April, 1927
New York Central R.R.	1	145	"	750	On order
New York Central R.R.	1	100	"	600	On order
Long Island R.R.	1	100	"	600	On order
Lehigh Valley R.R.	1	60	"	300	On order

These locomotives as indicated were all built, or are being built, by the Ingersoll-Rand, General Electric and American Locomotive companies, except the last one on the list, which is being built by the McIntosh & Seymour, General Electric and Brill companies.

General Dimensions of Three Specially Designed Diesel Engine Driven Locomotives Now on Order for an Eastern Railroad

Service	Freight	Passenger	Switch
Wheel Arrangement (Whyte)	4-8-4	4-8-4	0-4-4-0
Weight—On front truck	63,400	84,000	
—On drivers	164,000	180,000	250,000
—On rear truck	63,400	84,000	
Total of Locomotive	290,880	348,000	250,000
Total length overall	51'-7"	59'-4"	46'-8"
Maximum width	10'-0"	10'-0"	9'-10"
Maximum height	14'-4¼"	14'-4"	14'-7"
Driving wheel base	17'-6"	18'-6"	8'-3" 34'-1"
Total wheel base	42'-10"	49'-4"	34'-1"
Maximum speed M.P.H.	45	60	40
Maximum traction power (lbs.)	41,000	25,000	62,500
Factor of adhesion	25%	25%	25%
Kind and dia. wheels—driver	44" rolled steel	44" rolled steel	44" rolled steel
Kind and dia. wheels—truck	30" rolled steel	30" rolled steel	
No. and size axles—driver	4-7"x14"	4-7"x14"	4-8"x14"
No. and size axles—truck	4-6"x13"	4-7"x14"	
Engine, Kind—Cycle	4-stroke	4-stroke	4-stroke
—Maker	Ingersoll-Rand	McIntosh & Seymour	Ingersoll-Rand
Brake horsepower	750	960	300
Revolutions per minute	500	325	600
Piston speed, feet per minute	1333	975	1200
Cylinders diameter x stroke	14¾"x16"	14"x18"	10"x12"
No. of cylinders	6	12	6
Method of starting engine	Air	Air	Electric
Kind of starting motor	None	None	Generator (As a Motor)
Weight of engine, lbs.	45,000	80,000	20,125
Kind of heating system	Peter Smith IC Heater	Train Heating Oil-Fed Boiler	Peter Smith IC Heater
Kind and location of radiator	Vertical Fin Tube Type in cab	Modine Radiator Sides of Cab	Fin Tube Roof Type On Roof
Kind of fuel inj. system	Solid	Air	Solid
Main Power Generator—Type	DT 752	DT 751	
—Voltage	460	485	500
—R.P.M.	500	325	600
Storage Batteries—Number	14 Cells	14 Cells	218 Cells
—Type	E. S. B. Co. MVA-H9	E. S. B. Co. MVA-H9	E. S. B. Co. MVA-41
—Capacity	150 A.H.	150 A.H.	680 A.H.
Axle Motors—Number	4	4	4
—Location	Running Gear	Running Gear	On Truck
—Type	GE-286-A	GE-286-A	GE-286-A
—Capacity	395-H.P.	395-H.P.	395 H.P.
Control System—Kind	Gen. Elec-Type PCL	Gen. Elec-Type PCL	Gen. Elec-Type PCL
Control System—Single or Double	Multiple Unit Double End	Multiple Unit Double End	Double End

This list is complete except for several locomotives of special design which are described later in this report.

One Eastern Railroad included in the foregoing list has on order three Diesel engine-driven locomotives. These locomotives are of special design, as shown in the tabulation.

A second Eastern Railroad is now building in its own shops, as referred to in the first part of this report, three Diesel engine-driven locomotives. A general description of these locomotives is as follows:

Type	0-4-0
Length over couplers	26' 10½"
Wheel base	10'
Wheel diameter	50"
Weight	130,000 lbs.
Tractive effort	40,000 lbs.

OIL ENGINE

Bessemer 500 h. p. at 800 r. p. m. Type V, 4 cycle, solid fuel injection, 8 cylinders. Bore and stroke 8½" x 12".

ELECTRICAL EQUIPMENT

Main Generator, Westinghouse 325 kw. at 580 volts and 800 r. p. m.

Motors, two (2) Westinghouse 225 h. p. each.

Gear ratio 16:76.

Diesel Geared Locomotive—By Fried. Krupp. A. G. Essen, Germany

Dimensions	Type 4-8-4
Weights—Leading Truck	57,000 lbs.
Drivers	200,000 lbs.
Trailing Truck	57,000 lbs.
TOTAL	314,000 lbs.

Wheel Bases—Rigid	17'-0"
Truck	6' 6"
Total	44' 1"
Center to Center of Trucks	37' 7"
Driving Wheels—Diameter	61"
Truck Wheels—Diameter	33"
Tractive Power @ 7½ M.P.H.	50,000 lbs.
Factor of Adhesion	4
Maximum Curve	16°
Maximum Grade	1½%
Maximum Speed, level, straight track	60 M.P.H.

Engine

Diesel Type G M E V 43 c.m. /43 c.m.

Six cylinders, single acting, 4 cycle, airless injection, not less than 1300 B.H.P. at 470 r.p.m. Equipped with supercharges.

Transmission

Power is transmitted from the engine to the driving wheels by a mechanical 4-stage gear transmission system.

Three speed-change clutches, a part of the transmission system, are electro-magnetically operated and communicate motion to the jackshaft, the speed of which is determined by the selection of any one of the three clutches and the associated gear ratio. Gears are not shifted, but are constantly in mesh. When not engaged by their respective clutches gears turn idly on their bearings.

Solenoid clutches eliminate severe shocks of mechanical transmission in making speed changes.

The locomotive is to be arranged for multiple unit control and equipped for operation from either end.

The running gear of the locomotive wheels, connecting rods, axle boxes, etc., conform to the railroad company's practice and design.

This locomotive is to be suitable for either switching, freight or passenger service by the operation in proper order of the magnetic clutches, connecting the 1st, 2nd and 3rd stages for switching, and slow freight service, and the 2nd, 3rd and 4th stages for fast freight and passenger service. Delivery of the locomotive is expected the latter part of the year.

Notes on Domestic Railroads

Locomotives

The Monogahela Railway has ordered 6 Mikado type locomotives from The Baldwin Locomotive Works.

The New York Central is inquiring for 30, 4-6-4 type locomotives, 30, 4-6-2 type and 6 heavy type eight-wheel switching locomotives.

The Chicago Burlington & Quincy Railroad has ordered 12, 2-10-4 type locomotives from The Baldwin Locomotive Works.

The Chicago South Shore & South Bend Railroad has ordered 2 electric locomotives from the Westinghouse Electric & Manufacturing Corporation.

The Erie Railroad is reported to be inquiring for 50 heavy Mikado type locomotives and 30 switch engines.

The Bangor & Aroostook Railroad has ordered 5 Pacific type passenger locomotives from the American Locomotive Company.

The American Railroad of Porto Rico is inquiring for 2 narrow gauge locomotives.

The Illinois Central Railroad is inquiring for 15 eight-wheel switching type locomotives.

The Ferrocarrill de Antioquia, Colombia, South America, has ordered 2 Mikado type locomotives from The Baldwin Locomotive Works.

The Ferrocarrill de Antioquia, Colombia, South America, has ordered one consolidation type locomotive from the American Locomotive Company.

Passenger Cars

The Missouri Pacific Railroad has ordered one gas-electric power plant for installation in an existing rail motor car, from the Electro-Motive Company, Cleveland, Ohio.

The Lehigh Valley Railroad has ordered one combination passenger and baggage gasoline-electric rail motor car from the J. G. Brill Company, Philadelphia, Pa.

The Denver & Rio Grande Western Railroad has ordered one double unit power plant for a rail motor car from the Railway Motors Corporation, Depere, Wisc.

The Baltimore & Ohio Railroad has ordered four passenger and smoking, gas-electric rail motor cars 60 ft. long from the J. G. Brill Company, Philadelphia, Pa.

The Chicago & Illinois Midland Railway is inquiring for six miscellaneous passenger cars.

The Southern Pacific Company has ordered six dining cars from the Pullman Car & Manufacturing Corporation.

The Lehigh Valley Railroad has ordered one 60-ft. combination passenger and baggage gas-electric rail motor car from the Electro-Motive Company, Cleveland, Ohio.

The New York, New Haven & Hartford Railroad is inquiring for 20 baggage cars.

The Oahu Railway Company has ordered two single unit power plants for rail motor cars from the Railway Motors Corporation Depere, Wis.

The Chicago Springfield & St. Louis Railroad has ordered one gasoline rail motor car for passenger service and one combination baggage and trailer from the J. G. Brill Company, Philadelphia, Pa.

The Wabash Railway has ordered 2 steel coaches from the American Car & Foundry Company.

The Central Vermont Railway has ordered 2 combination passenger and baggage gasoline rail motor cars from J. G. Brill Company, Philadelphia, Pa.

The Reading Company is inquiring for 15 steel baggage cars.

The Chicago, North Shore & Milwaukee Railroad is inquiring for 10 double end two-men passenger cars.

The Illinois Central Railroad is inquiring for 6 baggage and mail cars and 10 baggage and express cars.

Freight Cars

The Illinois Central Railroad is inquiring for 500 50-ton cars, 1,000 50-ton gondola cars, 700 50-ton hopper cars, 300 75-ton hopper cars, 2,000 40-ton high box cars.

The Southern Pacific Company has ordered 10 extension side dump cars from the Clark Car Company.

The Reading Company is inquiring for 1,000 gondola cars.

The Delaware, Lackawanna & Western Railroad has ordered 300 steel hopper cars of 70-tons' capacity from the American Car & Foundry Company.

The American Sugar Refining Company has ordered 125 cane cars from the Magor Car Corporation.

The Chicago & Illinois Midland Railway is inquiring for 350 all steel gondola cars.

The St. Louis Southwestern Railway has ordered 20 additional caboose car underframes from the Virginia Bridge & Iron Company.

The Union Pacific Railroad is inquiring for 6 dump cars for service on the Oregon Short Line Railroad.

The Pere Marquette Railway has ordered 1,000 box cars from the Pressed Steel Car Company, 250 gondola cars from the Illinois Car & Manufacturing Company and 250 hopper cars from the Standard Steel Car Company.

The Minneapolis, St. Paul & Sault Ste. Marie Railway has ordered 150 gondola cars from the Pullman Car & Manufacturing Corporation.

The Southern Pacific System has ordered 500 sets of underframes and superstructures from the Greenville Steel Car Company.

The Union Tank Car Company has ordered 200 tank cars with 8,000 gal. capacity from the General American Car Company and 300 tank cars from the American Car & Foundry Company.

The Fruit Growers Express is inquiring for 650 underframes for refrigerator cars.

The Pennsylvania Railroad has recently placed an order for 50 cabin cars to be built at its own shops at Altoona, Pa.

The Georgia & Florida Railway is inquiring for about 80 box cars

The Lehigh & New England Railroad is inquiring for 200 box cars of 50-tons capacity and also for prices on repairs to 200 hopper cars.

The American Sugar Refining Company is inquiring for about 125 cane cars.

The Western Maryland Railway will build 1,000 hopper cars of 55-tons capacity in its own shops at Ridgely, West Va.

The Southern Railway has ordered 20 air-dump cars, drop-door type from the Pressed Steel Car Company, to be built at the Koppel plant.

The Minneapolis, St. Paul & Sault Ste. Marie Railway has ordered 100 gondola cars from the Siems Stembel Company.

The South Manchuria Railway has ordered 20 air dump cars of 45 cu. yd. capacity from the Magor Car Corporation.

The Chicago, South Shore & South Bend Railroad has ordered 6 flat cars from the Standard Steel Car Company.

The Chicago, Rock Island & Pacific Railway is inquiring for 100 underframes for ice cars.

The Guantanamo Sugar Company has ordered 30 box cars and 2 air dump cars from the Magor Car Corporation.

The Chicago, North Shore & Milwaukee Railroad has ordered 10 flat cars from the Standard Steel Car Company.

The Pacific Fruit Express has ordered 600 underframes from the Pacific Car & Foundry Company.

The Cornwall Railroad has ordered 20 ore cars of 70-ton capacity from the Bethlehem Steel Company.

The Boston & Maine Railroad has ordered 6 air dump cars of 30 cu. yd. capacity from the Magor Car Corporation.

The Union Railroad has contracted for the repairing of 670 hopper cars with the Greenville Steel Car Company.

The St. Louis Southwestern Railway has ordered 30 caboose car underframes from the Virginia Bridge & Iron Company.

The Sloss-Sheffield Steel & Iron Company is inquiring for 30 quadruple hopper cars of 50 tons capacity.

The Cambria & Indiana Railroad is inquiring for price on repairing 300 hopper cars.

The Standard Oil Company of New Jersey has ordered 10 steel box cars from the Pressed Steel Car Company.

The Chicago & Illinois Midland Railway plans to let contracts for repairing 240 gondola cars.

The New York Central Railroad has been getting prices on 1,000 box cars and 2,500 steel gondola cars.

The Mid-Continent Petroleum Corporation has ordered 8 tank cars from the American Car & Foundry Company.

Buildings and Structures

The Atchison, Topeka & Santa Fe Railway have plans for the construction of an addition to the enginehouse at Slaton, Texas, consisting of 6 stalls 124 ft. in length including engine pits provided with water, air, steam and boiler washing lines.

The New York, New Haven & Hartford Railroad, has awarded to Henry R. Kent & Co., Rutherford, N. J., a contract for the construction of a central boiler plant of New Haven, Conn., to cost approximately $500,000.

The Texas & Pacific Railway has awarded a contract for construction of buildings at the new freight terminal, yard and shop at Fort Worth, Texas to the Austin Company, Cleveland, Ohio.

The Boston & Albany Railroad has awarded a contract to the Fairbanks, Morse Company, Chicago, Illinois, for the construction of a coaling and sanding plant at Worcester, Mass.

The Atchison, Topeka & Santa Fe Railway have plans in the course of preparation for the construction of a general office building at Amarillo, Texas.

The Atchison, Topeka & Santa Fe Railway have plans for the construction of a frame engine house 96 ft. by 208 ft. with concrete engine pits, also additional locomotive sidings at Isom, Texas.

The Grand Trunk Western Railway contemplates the construction of a freight classification yard of 4,000 cars capacity on the line of its subsidiary, the Detroit, Grand Haven & Milwaukee, at Detroit, Michigan. The yard will be operated in conjunction with the recently constructed yard at Pontiac, Mich., and in the future all freight will move into Detroit, from Pontiac. The yard will be constructed by company forces, although the enginehouse and other buildings will be built by contract.

The Canadian National Railways has awarded a contract for the construction of a 300 ton reinforced concrete coaling station at Paris Junction, Ontario, Canada to N. McLeod, Ltd., Toronto, Canada.

The Kansas City, Mexico & Orient Railroad has awarded a contract for the construction of a passenger station at Ft. Stockton, Texas at a cost of about $30,000.

The Louisville & Nashville Railroad plans soon for the construction of a freight house at Mobile, Alabama.

The blacksmith shop, tool shop, and brass foundry at the Burnham shops of the Denver & Rio Grande Western Railroad at Denver, Colo., were damaged by fire to the extent of $25,000.

The Missouri Pacific Railroad plans the construction of a boiler house at Nevada, Mo., to cost approximately $10,000.

The New York, New Haven & Hartford Railroad has awarded a contract to the Roberts & Schaefer Company, Chicago, Ill., for the construction of a five-track reinforced concrete coaling and sanding plant at Cedar Hill Yard, New Haven, Conn. This plant will have a capacity of 2,400 tons with automatic electric elevating skips of a capacity of 150 tons per hour.

The St. Louis-San Francisco Railway has awarded a contract for the construction of reinforced concrete foundations for shop buildings, roundhouses, turntable, water tower and cinder pits at the new locomotive terminal at Yale, Tenn., has also awarded to the United Construction Company, Cincinnati, Ohio, at a cost of $60,000. Company forces will be employed in the construction of a seven-stall addition to the North side roundhouse and a 60-ft. extension to the west side coach house at Springfield, Mo., to cost approximately $100,000.

The Chicago, Rock Island & Pacific Railway have plans in the course of preparation for the construction of additional locomotive repair facilities at Silvis, Ill., to cost approximately $125,000.

The New York, Chicago & St. Louis Railroad has awarded a contract to Austin Company, Cleveland, Ohio, for the construction of a one-story steel frame warehouse building, at East Forty-fifth Street and Woodland Avenue, Cleveland, Ohio.

The shops of the Louisville & Nashville Railroad at Boyles, Ala., were damaged by fire to the extent of $100,000. The flames are said to have been started by a motor in the planing mill.

The Southern Railway has awarded a contract for the construction of coaling stations, sanding facilities and cinder-handling equipment to Fairbanks, Morse & Company, Chicago, Ill., at the following points. Monroe, Va., 1,000-ton reinforced concrete three-track coaling station; Columbia, S. C., 1,000-ton reinforced concrete four-track coaling station; Atlanta Junction, Ga., 800-ton reinforced concrete four-track coaling station; Bulls Gap, Tenn., 600-ton reinforced concrete three-track coaling station; Coster, Tenn., 500-ton reinforced concrete two-track coaling station; Sheffield, Ala., 500-ton reinforced concrete three-track coaling station; Jacksonville, Fla., 300-ton steel three-track coaling station with yard storage for 5,000 tons of coal; Lawrenceburg, Ky., 300-ton steel two-track coaling station; Winston-Salem, N. C., 300-ton steel two-track coaling station. Each of the reinforced concrete coaling stations will have storage space for 100 tons of wet sand and 20 tons of dry sand and each of the steel coaling stations will have storage space for 100 tons of wet sand and 10 tons of dry sand. Electric single-track cinder-conveying units will be installed at Columbia, Atlanta Junction, Winston-Salem and Jacksonville.

Items of Personal Interest

Albert E. Jones, general foreman of the Chicago Great Western Railroad, with headquarters at St. Paul, Minn., has been promoted to superintendent of the shops at Oelwein, Iowa.

J. C. Mengel, master mechanic of the machine shops of the Pennsylvania Railroad at Altoona, Pa., has been appointed assistant to the works manager. **O. N. Edmondson**, general foreman of the erecting and machine shops at Juniata, Pa., succeeds **Mr. Mengel** at Altoona.

Marvin Wilcox has been appointed assistant superintendent of car maintenance of the Boston & Maine Railroad.

I. C. Blodgett, also assistant to the mechanical superintendent of the Boston & Maine Railroad with headquarters at Boston, Mass., has been appointed supervisor of schedules, reporting to the assistant to the mechanical superintendent.

B. C. Crow, general superintendent of the Weatherford Mineral Wells & Northwestern Railway has been appointed superintendent of the Cisco & Northeastern Railway with headquarters at Cisco, Texas.

Frank Reardon has been appointed acting transportation inspector of the Albuquerque division of the Atchison, Topeka & Santa Fe Railway with headquarters at Winslow, Ariz.

O. D. Gephart has been appointed inspector of transportation of the Denver & Rio Grande Western Railroad with headquarters at Denver, Colo.

H. C. Caswell, general foreman of the Wabash Railway with headquarters at Detroit terminals has been appointed superintendent of the Decatur locomotive shop at Decatur, Ill.

J. O. McPake has been appointed master mechanic of the Toledo, Peoria & Western Railway with headquarters at Peoria, Ill., succeeding **F. R. Echard.**

H. C. Murphy, engineer of maintenance of way of the lines of the Chicago, Burlington & Quincy Railroad with headquarters at Lincoln, Nebr., has been appointed transportation assistant on the staff of the general manager with headquarters at Omaha, Nebr.

J. G. Watson has been appointed assistant secretary of the Pennsylvania Railroad with headquarters at Philadelphia.

C. B. Smith, assistant to the mechanical superintendent of the Boston & Maine Railroad with headquarters at Boston, Mass., has been appointed engineer of tests.

F. T. Buechler has been appointed superintendent of the Dakota division of the Chicago, Milwaukee & St. Paul Railway with headquarters at Sioux City, Iowa.

Charles H. Wiggin, consulting mechanical engineer of the Boston & Maine Railroad has retired after 45 years of service.

H. D. Handley, acting superintendent of the Southern Pacific Railroad of Mexico, has been promoted to superintendent with headquarters at Empalme, Son., Mexico.

Ralph F. Ray has been appointed assistant general manager of the Denver & Rio Grande Western Railroad.

L. C. Winship, electrical superintendent and supervisor of power plants of the Boston & Maine Railroad, with headquarters at North Adams, Mass., has been appointed electrical engineer.

A. K. Galloway, district master mechanic of the Baltimore & Ohio Railroad, with headquarters at Baltimore, Md., has been appointed superintendent of the motive power of the Western lines, with headquarters at Cincinnati, Ohio, succeeding W. Malthaner. **G. R. Galloway**, district master mechanic of the Southwest district with headquarters at Cincinnati succeeds **A. K. Galloway.**

I. B. Chadwick has been appointed superintendent of the Southern division of the Ohio Central lines of the New York Central Railroad with headquarters at Charleston, West Va.

S. P. Henderson, superintendent of the Northern division of the Chicago & Alton Railroad with headquarters at Bloomington, Ill., has been appointed general superintendent with the same headquarters, succeeding **W. H. Penrith.**

O. M. Helper has been appointed assistant to the controller of the Chesapeake & Ohio Railroad with headquarters at Richmond, Va.

E. J. McSweeney, master mechanic of the Baltimore & Ohio Railroad, with headquarters at Akron, Ohio, has been appointed district master mechanic of the Southwest district.

G A. Austin, general superintendent of the Gainesville & Northwestern Railroad has been appointed receiver and general manager with headquarters at Gainesville, Ga.

J. J. Butler, assistant superintendent of the Chicago & Alton Railroad with headquartesr at Bloomington, Ill., has been appointed superintendent of the Northern division with the same headquarters.

Lawrence Richardson, assistant to the president of the Boston & Maine Railroad has been appointed mechanical superintendent in charge of the locomotive and car departments with headquarters at Boston, Mass., succeeding **W. O. Forman,** who has joined the staff of Manning Maxwell & Moore, Inc.

Harry Rees, general foreman of the locomotive department of the Baltimore & Ohio Railroad at New Castle Junction, Pa., has been appointed master mechanic at Akron, Ohio.

Henry H. Urbach has been appointed superintendent of motive power of the Chicago, Burlington & Quincy Railroad with headquarters at Lincoln, Nebr.

Albert Ewing has been appointed assistant general manager of the Western district of the Eastern lines of the Atchison, Topeka & Santa Fe Railway with headquarters at Topeka, Kan.

H. C. Gugler, master mechanic of the Chicago, Burlington & Quincy Railroad with headquarters at Sheridan, Wyo., has been transferred to the Hannibal division with headquarters at Hannibal, Mo.

C. J. Blanthorn has been appointed supervisor of the wage bureau of the Long Island Railroad with headquarters at New York city succeeding **J. W. Slack, Jr.**

Daniel J. Ayers, master mechanic of the Boston & Maine Railroad with headquarters at Woodville, N. H., has been appointed supervisor of locomotive performance with headquarters at Boston, Mass., succeeding **John W. McVey,** who has been appointed master mechanic with headquarters at East Somerville, Mass.

Albert J. Farrelly, electrical engineer of the Chicago & Northwestern Railway for the past 28 years, has retired under pension rules after nearly 50 years of service. **Joseph A. Andreucetti** who has been assistant electrical engineer of the road succeeds Mr. Farrelly.

John McFayden, master mechanic of the Columbia district of the Canadian Pacific Railway with headquarters at Nelson, B. C., has been transferred to Vancouver, B. C., succeeding W. H. Evans, retired. **Palmer S. Lindsay,** master mechanic of the Manitoba district with headquarters at Winnipeg, Man., has been transferred to Nelson, B. C., to succeed **J. McFayden.**

Thomas H. Carrow, the safety specialist of the Pennsylvania Railroad connected with the insurance department, has been promoted to the newly created position of superintendent of safety with headquarters at Philadelphia, Pa.

W. H. Ohnesorge has been appointed master mechanic, Fitchburg Berkshire division of the Boston & Maine Railroad, with headquarters at East Deerfield, Mass. **E. J. Dwyer** has been appointed master mechanic White Mountain, Passumpsic and Connecticut divisions with headquarters at Springfield, Mass.

D. VanHecke, superintendent of the Panhandle division of the Chicago, Rock Island & Pacific Railroad with headquarters at El Reno, Okla., has been appointed superintendent of the newly created Panhandle division with headquarters at Amarillo, Texas.

Supply Trade Notes

The Combustion Engineering Corporation, Ladd Water Tube Boiler Company and the **Heine Boiler Company** have been consolidated and will be located at 1107 Guardian building. **Frank Henderson** is Cleveland district manager of these three associated companies.

J. H. Gleason, sales manager of the Chicago district of the **Graybar Electric Company,** has assumed charge of the railroad relations of the Chicago district.

J. P. Armstrong, with offices in the Balboa Building, San Francisco, Calif., will represent the **Flannery Bolt Company** in that district, handling staybolts.

The Air Reduction Sales Company, New York City, has acquired the **Interstate Oxygen Company,** a West Virginia corporation, with acetylene plants at Wheeling, W. Va., Steubenville, Ohio, and Portsmouth, Ohio; also the **Compressed Gas Manufacturing Company,** a West Virginia corporation, having an acetylene plant at Huntington, W. Va.

E. G. Bailey is president of the new **Bailey Meter Company,** Cleveland, Ohio. **R. S. Coffin** is vice-president and **R. E. Woolley** is vice-president in charge of sales and engineering.

John A. Hatfield has been chosen president of the **American Bridge Company,** succeeding **August Ziesing, retired, L. A. Paddock** and **F. B. Thompson** become vice-presidents.

The Verona Tool Works, Pittsburgh, Pa., has moved its general offices to First National Bank building, Pittsburgh, Pa.

A. P. Hagar of the **Safety Car Heating & Lighting Company,** with headquarters at New York, has been appointed representative, with the same headquarters, reporting to the manager of the northeastern district sales office.

The Commercial Acetylene Supply Company, New York City, announces that after May 1, the main office of the company will be located at 71 Broadway, New York City. The new telephone number will be Bowling Green 5364.

The National Railway Appliance Company has removed its office from 452 Lexington Avenue, to the Graybar building, 420 Lexington Avenue, New York City.

G. N. Brill has been appointed district manager of the **Lincoln Electric Co.,** in charge of the New York office. **S. W. Schultz** is now in charge of the Lancaster office and **E. J. Pfister** in charge of the Philadelphia office.

The Mudge & Company, Chicago, has awarded contracts for an addition to its manufacturing plant at Chicago. When completed, the plant will have double the productive capacity of the present plant.

Charles A. Fisher, vice-president of the **Jones & Laughlin Steel Corporation** has been elected president with headquarters at Pittsburgh, Pa., to succeed the late **W. Larimer Jones.**

The Equipment Sales Corporation, Railway Exchange Building, St. Louis, Mo., has been appointed sales representative for the **Flannery Bolt Company** of Pittsburgh, Pa.

A. P. Sweeney, formerly assistant secretary of the Mechanical division of the **American Railway Association,** has become affiliated with **Batchelder & Company,** Chicago.

The **R. H. Beaumont Company,** Philadelphia, Pa., has taken over the business of the **American Manufacturing & Engineering Company,** of Kalamazoo, Michigan. **S. O. Nafziger,** president of the **American Manufacturing & Engineering Company,** will be associated with the **R. H. Beaumont Company.**

At a meeting of the board of directors of the **Gould Coupler Company, G. L. Davis** was elected vice-president in charge of sales, with headquarters at 250 Park avenue, New York City. Mr. Davis was formerly with **Scullin Steel Company,** as vice-president in charge of sales.

The Bird Archer Company has removed its offices from 33 Rector street to the Corn Exchange Bank Building, 1 East 42nd street, New York City.

W. O. Forman, recently mechanical superintendent of the Boston & Maine Railroad has entered the service of the **Manning, Maxwell & Moore, Inc.,** as assistant to vice-president Frank J. Baumis.

T. L. Miller, in charge of the Western office of **Tuco Products Corporation** at Chicago, has been elected vice-president and **C. M. Schramm,** assistant to the vice president of the **Vapor Car Heating Company,** has been elected vice-president of the Tuco Products Corporation.

The Pittsburgh Testing Laboratory has opened a new inspection headquarters and physical testing laboratory at Youngstown, Ohio, in charge of **H. L. Christman.**

Alexander Laughlin has been elected chairman of the board of the **Verona Tool Works,** and W. L. Mellon has been elected a director to succeed **Alexander Laughlin, Jr.,** deceased.

August Ziesing has retired as president of the **American Bridge Company.**

The Southern Wheel Company has removed its general offices from Pittsburgh, Pa., to Grand Central Terminal, New York City, N. Y.

R. H. Clore has been appointed a representative of the **United States Electrical Tool Company** at Cincinnati, Ohio. **Mr. Clore** was formerly with the **National Carbon Company.**

J. G. Carruthers has been elected vice-president of the **Otis Steel Company,** Cleveland, Ohio.

The Davis Brake Beam Company, Johnstown, Pa., has moved its Pittsburgh, Pa., office from 427 Oliver building to its own building at 418 Sixth Avenue.

Joshua D'Esposito, formerly chief engineer and general manager of the **Chicago Union Station Company**, has opened an office for the practice of general engineering at Chicago.

The Youngstown Sheet & Tube Company and the **Youngstown Steel Products Company**, Youngstown, Ohio, have moved their district sales office to suite 214-220 Continental Oil building, Denver, Colo.

J. de N. Macomb, office engineer of the Atchison, Topeka & Santa Fe Railway, has resigned to become assistant to the vice-president in charge of railroad sales of the **Inland Steel Company**, Chicago, effective May 15.

Charles Chandler, assistant engineer of bridges of the Illinois Central Railroad has resigned and has become associated with **J. G. Brill Company**, Philadelphia, Pa., as salesman in the automotive car division with territory in southeastern United States.

Dwight W. Morrow, of **J. P. Morgan & Company**, and **Victor M. Cutter**, president of the **United Fruit Company**, have been elected directors of the **International General Electric Company; Gerard Swope**, president of the **General Electric Company**, was elected chairman of the board, succeeding the late **Anson W. Burchard; Clark H. Minor** was re-elected president; **Walter J. Edmonds**, controller, was elected a new vice-president in charge of financial relations and **E. F. Colyer** was appointed controller.

J. P. Alexander, manager of the New Haven, Conn., branch office of the **Westinghouse Electric & Manufacturing Company**, East Pittsburgh, Pa., has been appointed Boston manager in charge of all sales and service in New England, with headquarters at Boston, Mass. Mr. Alexander has been associated with the Westinghouse Company for twenty years. George H. Cox, New England manager for the past eight years, has been appointed sales manager at the South Philadelphia Westinghouse Works, in charge of the sales of all the products manufactured at the plant, including steam turbines, condensers, Diesel engines, etc.

The Westinghouse Electric & Manufacturing Company on April 26 opened its new Westinghouse building at 267 North Pennsylvania avenue, Wilkes-Barre, Pa. The sales department, formerly in the Miners Bank building, is now on the second floor of the new building and the entire first floor is occupied by the service shop, which is equipped with the latest design of tools and equipment.

Obituary

William Goodman, vice-president of the Worthington Pump and Machinery Corporation, New York, died on April 21 in New York City. He was born in Cincinnati, Ohio. He graduated from Harvard University in 1896, and entered the engineering department of the Laidlaw, Dunn, Gordon Company of Cincinnati and when that organization was absorbed by the Worthington Corporation, he became general manager of the Cincinnati branch.

He was transferred to New York in 1918 as assistant to the vice-president, and four years later, was elected vice-president. Under the supervision of Mr. Goodman, the Worthington Corporation's engineers developed the new double acting Diesel engine and the feather valve air compressors and other engineering devices were also developed under Mr. Goodman. He was on active duty in the Spanish-American War as an ensign in the Navy, and during the World War offered his services as an engineer and was placed in charge of the manufacturing of munitions at the Worthington plant, Hazelton, Pa.

Leon P. Feustman, vice-president of the Worthington Pump and Machinery Corporation for many years, died at his home on April 7th. Mr. Feustman was born in Philadelphia May 6, 1861. He graduated from the University of Pennsylvania in 1882. Mr. Feustman was connected with the Consolidated Smelting & Refining Company for a few years. In 1903 he became vice-president of the Power & Mining Machinery Company and in 1907 he was elected vice-president and general manager of the International Steam Pump Company with which the Power & Mining Machinery Company was merged and through the reorganization in 1914 became known as the Worthington Pump and Machinery Corporation. Mr. Fuestman served with this company until he retired a short time before his death.

Frederick Weston of the Baldwin Locomotive Works at Philadelphia, and formerly in charge of the New York Office, died at Philadelphia, Pa., on April 17. Mr. Weston graduated from Yale University in 1900 and had been associated with the Baldwin Locomotive Works since.

Horace E. Wood, formerly treasurer and assistant secretary of the Chicago & Alton Railroad, retired, died on April 29 at Oakland, Calif., at the age of 72 years, after a short illness. He was born in Brooklyn, N. Y., and entered railway service in 1872 as a clerk in the treasurer's office at Chicago, Ill. Mr. Wood was elected secretary and treasurer of the Alton Railroad, the Joliet & Chicago Railway and the Mississippi River Bridge Company and upon reorganization of the Chicago & Alton Railway was elected assistant treasurer of that road. In 1907 he was appointed assistant treasurer same road, now called the Chicago & Alton Railroad, also assistant treasurer Toledo, St. Louis & Western Railroad, from 1908 to 1912 also assistant secretary. From 1908 to 1913 secretary and treasurer Kansas City, St. Louis & Chicago Railroad and also treasurer Rulland, Toluca & Northern Railroad and the Peoria Railway Terminal Company. Mr. Wood moved his home from Chicago to Oakland in 1924 where he remained until his death.

S. P. Alquist, master car builder of the Delaware, Lackawanna & Western Railroad with headquarters at Scranton, Pa., died on May 4. Mr. Alquist was born in Sweden, May 10, 1874. He was first with the Illinois Central Railroad as car repairer in 1895. In 1897 he was appointed change inspector until 1900. He then became assistant general foreman of car repairs, a position he held until 1910 when he was appointed general foreman of the car department and in 1911 he was appointed general foreman and chief inspector of the car department of the Pere Marquette. He was then appointed superintendent of the car department of the Missouri-Kansas-Texas Railroad returning to the Pere Marquette in 1917 as master car builder and later became master car builder for the Delaware, Lackawanna & Western Railroad in July, 1924, which position he held until his death.

Frederick H. Thatcher, eastern district sales manager of the Worthington Pump & Machinery Corporation died suddenly on May 2, at Cincinnati, Ohio. Mr. Thatcher was born in New Canaan, Conn. He graduated from Cornell in 1895. Mr. Thatcher had been with the Worthington Pump & Machinery Corporation and its predecessors for thirty years.

New Publications

Books, Bulletins, Catalogues, etc.

Metal Statistics, 1927 (Twentieth Annual Edition). Published by American Metal Market Company, 71 Cliff Street, New York City. Price $2.00.

This edition of "Metal Statistics" contains the same general assortment of statistical information concerning ferrous and non-ferrous metals that has been supplied in previous years, but various new tables have been introduced which it is hoped will further increase the publication's usefulness to the trade.

The aim each year is to furnish statistics providing the information most generally required by producers and consumers, buyers and sellers of metals and iron and steel products, and the editors are always pleased to receive suggestions looking to alterations or additions that would improve the book.

Attention is directed to the fact that the prices given in this book are based on the daily quotations appearing in the "American Metal Market," the market authority, and represent wholesale selling prices.

All the iron and steel production statistics are gathered by the American Iron and Steel Institute, while the production statistics on metals are for the most part based on figures furnished by the Bureau of Mines (formerly by the United States Geological Survey) and the American Bureau of Metal Statistics, and special thanks are due to these authorities for the very complete records of production which they supply to the public each year. It also contains a buyer's directory and index.

The 39th Annual Report on The Statistics of Railways in the United States, For the Year Ended December, 1926, prepared by Bureau of Statistics, Interstate Commerce Commission. Washington, Government Printing Office, Price 25 cents. Includes some 1926 statistics also compiled from monthly reports from the carriers, and the usual detailed statistical tables.

A Practical Guide for the Foundryman:—By Eugene W. Smith, General Superintendent of the Chicago works of Crane Co. This practical guide for the foundryman is 5½ by 7½ inches, stoutly bound in cloth. It is published by the author and may be ordered through The Foundry, The Valve World, or direct from the author, in care of Crane Co., Chicago. The price is five dollars.

Mr. Smith has put his experience and observation of half a century in handling sand in the foundry into a book of 190 pages, every page literally packed with the most practical information for the foundryman. The value of the book may be judged best from the following review which appeared recently in The Foundryman, the authoritative organ of the foundry world:

"This attractively bound book covers a far wider range even than is indicated by the full title, Foundry Sand—Its Uses and Abuses. Eugene W. Smith has investigated every phase of the sand question for a period of many years. As a result of his observations he developed what is known as the vibratory test, a simple method of determining the relative quantities of sand grains and bonding material in any given sample of sand.

"The author bluntly states in the beginning that the book is not merely a compilation of results of laboratory experiments, but deals with ordinary foundry problems in ordinary foundry language. It is written in what has come to be recognized and accepted as popular magazine and newspaper style, short chapters and short paragraphs, usually one sentence to a paragraph. For example, the first 100 pages are covered under almost as many chapter headings, dealing among other things with a description of the vibratory test and how the results may be interpreted when taken in connection with the scrap heap and the condition of the castings. Typical sources of trouble caused by sand are described and the obvious remedies are suggested. An exceptionally illuminating chapter is devoted to gates, how their shape, size, position and number affect the castings.

"Descriptions of sand specimens from practically every state in the Union occupy the second half of the book. Each description carries the name of the state, the particular deposit from which the sample was taken, the color, the purpose for which the sand particularly is adapted and the amount of bond and silica as determined by the vibratory test. The book should find a free and ready acceptance among foundrymen wanting essential facts boiled down and ready to serve.'

The Locomotive of To-day:—The Locomotive Publishing Company, Ltd., 3 Amen corner, Paternoster Row, E. C. 4, London, England. Price $1.50.

In this the eighth edition the publishers have brought the subject up to date according to present day locomotive practice. The book is written in a style appreciated by students, engineers, locomotive men, and those generally who desire to extend their knowledge of the modern steam locomotive. The book has been divided into sections which deal with the various parts of the locomotive, as follows: Boiler; Cylinders and Motion; Frames; Tenders and Tanks; Articulated Locomotives. A folding sectional plate is included, showing a London & North Eastern Railway, Gresley design 4-6-2 type locomotive, with the details numbered to correspond with the key provided underneath, together with a large number of other detail drawings. Feedheaters and appliances, live steam and exhaust injectors, mechanical lubricators, etc., are all to be found represented in this book.

Instruction Manual, Arc-Welding. Published by the Lincoln Electric Company, Cleveland, Ohio. Price $1.00 per copy. The Instruction Manual for electric arc welding is revised to cover the latest practices and is of interest to every one who employs the arc-welding process. The subjects treated are: High-speed steel welding; high pressure pipe welding; automobile frames; boiler repairs; welding cast iron; manganese steel welding; carbon arc welding and the manufacture of machinery and equipment, using welded steel in place of castings. This manual is intended for the use and information of the electric welder and contains much information of value in railroad shop work. All students of the development of Arc-Welding will derive much knowledge from this volume.

Tool Foremen's Proceedings:—Edited by G. G. Macina, secretary-treasurer, 11402 Calumet Ave., Chicago, Ill. Price $2.50 per copy.

This book contains a report of the fourteenth annual convention of the American Railway Tool Foremen's Association held at Chicago, September, 1926. In addition to a number of important addresses on the tool foreman's work the book contains committee reports presented at the last annual meeting together with the subsequent discussion. Drawings are included of the recommended standard boiler taps. The book is well arranged and indexed for convenient reference.

Information for Enginemen:—A booklet designed to assist railroad enginemen in the operation of the Worthington Locomotive Feedwater Heater has just been issued by the Worthington Pump and Machinery Corporation. It is this corporation's policy to place in the hands of the enginemen condensed information on the operation of the Worthington Locomotive Feedwater Heater. The first section of this vest pocket size booklet shows the benefits derived by the enginemen through the use of the Feedwater Heater. The next two sections are devoted to instructions for the operation of the Heater and the best methods of handling operating troubles on the road. The last section gives Worthington Heater cab gauge indications. A request, addressed to the Worthington Pump Corporation, 115 Broadway, New York, will bring a copy of this booklet BK-1617.

Welding and Cutting Equipment:—The Smith Welding Equipment Company, Minneapolis, Minn., have just put out their new 1927 Junior Catalog of welding and cutting equipment. The new booklet is of convenient pocket size. It illustrates, describes and quotes prices on special outfits and other equipment to meet many requirements.

Ash Reclaiming Plants:—The Roberts & Schaefer Company, Chicago, has issued a bulletin describing and illustrating its "Kolumbus" separator for recovering combustible fuel from ashes by a flotation process. It is said to reclaim 30 per cent of unconsumed fuel from the ashes dumped from locomotives or power plants furnaces, and at the plant it is said to have been over the cost of the investment after making allowance for operating costs, fixed charges and depreciation.

Fifty Years of Service:—Is the title of an illustrated booklet of 168 pages recently issued by the Western Wheeled Scraper Company of Aurora, Ill. The booklet is a historical review of the company and its splendid development since 1877. As might be expected, a large share of the pages are illustrated and describe the present-day products of this experienced concern.

Railway and Locomotive Engineering

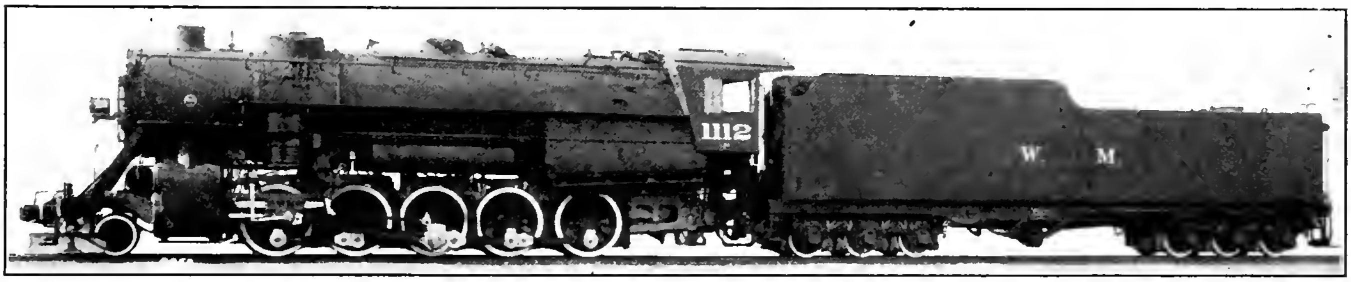
A Practical Journal of Motive Power, Rolling Stock and Appliances

Vol. XL — 136 Liberty Street, New York, June, 1927 — No. 6

Decapod Type Locomotives for the Western Maryland Railway

Develop 90,000 lb. Tractive Effort — Have High Capacity Tenders

In 1921, the Western Maryland placed in service forty Consolidation type locomotives, which were built by The Baldwin Locomotive Works. The tractive force developed was 68,200 pounds, and the locomotives proved so satisfactory that ten more, of the same general dimensions, were built in 1923. These locomotives still rank among the most powerful of their type in service; but in point of capacity they have recently been outclassed, on this road, by 20 Decapod type locomotives, built by The Baldwin Locomotive Works. The increase in tractive force, in the new design, is 32 per cent, and the steaming capacity has been increased in similar proportion, as the following table shows:—



Decapod or 2-10-0 Type Locomotive of the Western Maryland Railway—Built by The Baldwin Locomotive Works

Type	Cylinders	Drivers, diam.	Steam pressure	Grate area	Water Heating Surface	Superheating surface	Weight in Drivers	Weight total engine	Tractive force
2-8-0	27" x 32"	61"	210	74.9	3498	945	268,200	294,900	68,200
2-10-0	30" x 32"	61"	225	104.5	4431	1248	386,800	419,280	90,000

The boiler of the Decapod type is particularly notable because of its large firebox. The first course of the barrel is conical, increasing the diameter from 92 inches at the smokebox to 104 inches at the dome ring. The shell plates are 1 and 1 1/16 inches thick. The firebox has a combustion chamber 46 inches long, and the crown and sides, and combustion chamber, are all in one piece. No arch is used in this firebox, but a brick wall is built across the rear of the combustion chamber. The inside throat sheet is welded in, and the tubes and flues are welded at the firebox end. Flexible stay-bolts, 775 in number, are used in the breakage zone, and the front end of the combustion chamber crown is supported on four rows of flexible expansion stays. A Standard stoker is applied with the stoker engine placed on the tender.

The steam distribution is controlled by 14-inch piston valves, which are operated by Walschaerts motion. The valves have a steam lap of 1 1/8 inches, with no exhaust lap or clearance; and are set with a travel of 7 inches and a lead of 3/16-inch. The back ends of the main rods, and the side rod connections on the main pins, have floating bushings. The crank pins are heat treated. Baldwin special cast iron is used for piston and valve packing rings, and cylinder and steam chest bushings.

These locomotives are designed to operate on grades of 3½ per cent and curves of 16 degrees. Plain tires are used on the middle (main) pair of drivers, and the play between rails and flanges is 7/8 inch on the front and back drivers, and 3/4 inch on all other wheels under the locomotive and tender. The leading engine truck is of the constant resistance type.

Mention should be made of certain equipment details applied to these locomotives. The sand box is piped to deliver sand ahead of the front and main drivers, and back of the main drivers. Rail washing pipes are also applied. The lubricator is of the mechanical type, with one feed to each valve, one to each cylinder, one to the stoker engine and one to the air pump steam line. A drifting throttle is applied, with a two-inch pipe which is tapped into the right side of the dome. A shut-off valve is placed in the dome, and the line valve has an extension handle to the cab. To provide fresh air in the cab while passing through tunnels, a "breather pipe," connected to the air reservoir line, is placed across the boiler back head. This pipe has five ½-inch globe valves, equally spaced, and each connected to three feet of hose. The steam turret is placed outside the cab, and the valves most frequently used are fitted with extension handles.

Further details of the locomotive are given in the accompanying table:

Table of Weights and Dimensions of Western Maryland Decapod Type Locomotive

Cylinders	30 x 32 ins.	
Valve	Piston, 14 ins. diam.	
Boiler		
Type	Wagon top	
Diameter	92 ins.	
Working pressure	225 lbs.	
Fuel	Soft Coal	
Firebox		
Material	Steel	
Staying	Radial	
Length	131⅞ ins.	
Width	114 ins.	
Depth front	90½ ins.	
Depth back	70½ ins.	
Tubes		
Diameter	5½ ins	2¼ ins.
Number	64	252
Length	17 ft. 0 in.	17 ft. 0 in.
Heating Surface		
Firebox	258 sq. ft.	
Combustion Chamber	102 sq. ft.	
Tubes	4,071 sq. ft.	
Total	4,431 sq. ft.	
Superheater	1,248 sq. ft.	
Grate area	104.5 sq. ft.	
Driving Wheels		
Diameter outside	61 ins.	
Diameter center	53 ins.	
Journals, main	13½ x 14 ins.	
Journals, others	11 x 14 ins.	
Engine Truck Wheels		
Diameter	33 ins.	
Journals	7 x 12 ins.	
Wheel base		
Driving	22 ft. 6 ins.	
Rigid	22 ft. 6 ins.	
Total Engine	32 ft. 10 ins.	
Total engine and tender	92 ft. 9½ ins.	
Weight in working order		
On driving wheels	386,800 lbs.	
On truck	32,480 lbs.	
Total engine	419,280 lbs.	
Total engine and tender	835,200 lbs.	
Tender		
Wheels number	Twelve	
Wheels diameter	36 ins.	
Journals	7 x 14 ins.	
Tank capacity	22,000 U. S. gal.	
Fuel	30 tons	
Tractive force	90,000 lbs.	
Service	Freight	

In lieu of a pilot, a specially designed "snow guard," built of steel plate, is placed under the front bumper, with a foot-board on each side.

The tender is one of the largest thus far built, as it has capacity for 22,000 gallons of water and 30 tons of coal. The frame is a one-piece, Commonwealth steel casting, and the trucks are of the six-wheeled, Commonwealth type, equipped with clasp brakes. The tender truck axles, as well as the axle of the engine truck, are of heat treated steel. It is interesting to compare the capacity of these tenders with those of the Consolidation type locomotive built in 1921. The latter carried 15,000 gallons of water and 16 tons of coal, and were considered of exceptional capacity at the time of their construction.

The new Decapod locomotives have a height overall of 16 feet 2 inches, and a width overall of 11 feet 2 inches. The total length over the faces of the engine front bumper and the tender rear bumper, is 100 feet 4¾ inches.

Norfolk & Western High Capacity Tenders

Thirty of the largest locomotive tenders ever designed for service on the Norfolk and Western Railway will be constructed at Roanoke Shops in the near future, according to an announcement recently made at the General Offices of the railroad at Roanoke, Va. The new tenders will carry 18,000 gallons of water and 26¼ tons of coal and are being built by the railroad's forces as part of its program to give continuous employment to shop forces.

In October, 1926, work was started at Roanoke Shops on 30 locomotive tenders of 16,000-gallon, 23-ton capacity, 20 of which have been completed and placed in service. These tenders are being turned out at the rate of one a week and it is expected that by the time they are completed the materials will be available for work on the larger tenders.

The new 18,000-gallon, 26¼-ton capacity tenders will be the largest in service on the Norfolk and Western and with few exceptions the largest tenders in use on any railroad in the United States. The additional capacity has been obtained by lengthening the tender 3 feet, 9½ inches, necessitating some changes in design although the new tenders, in appearance, will be similar to those now in service.

Some idea of the size of these new tenders, which play an important part in the efficiency of train operation, may be gained from the following dimensions: The cistern of the tender is 40 feet, 3 inches long (3 feet, 9½ inches longer than the 16,000-gallon tender); 10 feet, 5½ inches wide and 7 feet, 8 inches high. The width and height of the new tender is the same as that of the 16,000-gallon tender now in service. The total length of the new tender is 44 feet, 7¼ inches. When coupled to a Mallet locomotive, the entire power unit will be 102 feet, ¼ inch in length. The weight of the tender loaded will be approximately 314,300 pounds and its light weight (unloaded) will be 110,800 pounds.

Special Design Flat Cars of the Pennsylvania

The Pennsylvania Railroad has just arranged for the construction of twelve flat cars of special design, and possessing features of unusual interest. The cars will be built with depressed centres, for the particular purpose of carrying shipments of great weight and large dimensions.

Two of these cars will be of the type known in the road's classification as "F28." This class of car is designed primarily for shipments of armatures, turbo-generators, transformers and large castings, and will have a carrying capacity of 275,000 pounds. The bulk of the shipments will be carried in the central depressed portion, which is 25 feet in length and 6 feet 8 inches wide between the side sills.

The height of the car has been restricted to the minimum for the lading to be carried, in order to keep the center of gravity of the car and its load as low as possible.

The length of the car body is 52 feet 6 inches and total length of car 54 feet 6½ inches. Car will be equipped with six-wheel trucks of special design.

A New Design of Light Steam Locomotive

A New Type of Prime Mover for Branch Line and Switching Service

The demand for greater economies in railway operation in countries other than United States has resulted in many departures from what may be called conventional lines in motive power designs, and this is no where more pronounced than in recent developments in England, to meet the requirements for branch line or suburban passenger service and switching or light industrial service, where both the weight and expense of operating the conventional type of steam locomotive was prohibitive.

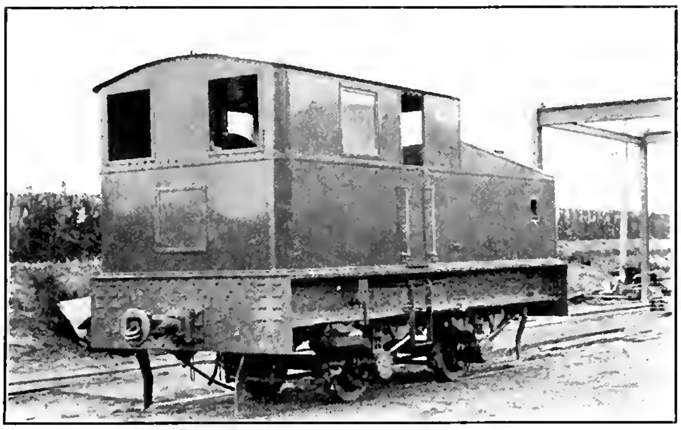


Fig. 1—200 H.P. "Sentinel" Locomotive in Service in South Africa

A most striking illustration of what can be accomplished in this direction is the new switching locomotive and steam motor coach developed by The "Sentinel" Waggon Works, Ltd., Shrewsbury, England.

This new development of switching or shunting locomotive, as our English cousins designate it, has been adapted to various uses in many countries aside from the home of its production. We are indebted to the builders for the description and photographs of the engine and its application in switching service.

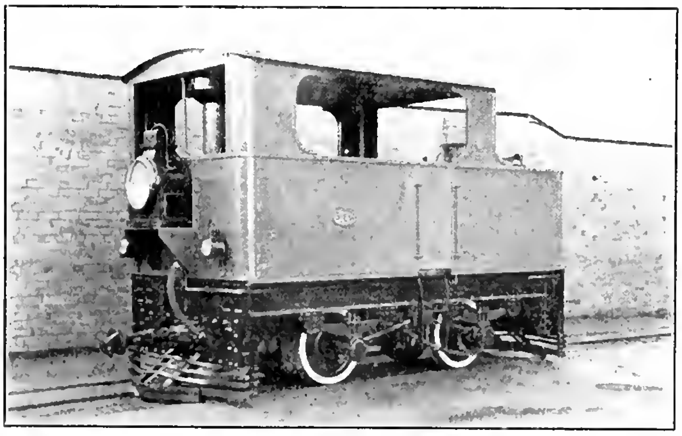


Fig. 2—100 H.P. "Sentinel" Locomotive with Open Cab for Service in the Tropics

Railway locomotives are designed primarily for high speed work on long lengths of lines, and it is scarcely necessary to say that they serve their purpose admirably. Switching locomotives have a different kind of duty to perform altogether as they are meant to handle small lots of rolling-stock in comparatively restricted areas, yet the switching engine is built to the same general design as its high speed brother. In the main line locomotive the boiler has necessarily been designed so that its great bulk can be accommodated in tunnels, etc., of standard dimensions, and that one revolution of wheels should be given by each cycle of the engine is essential to the call for speed. As a switching locomotive is not called upon to fulfill either of these requirements, it is rather surprising that the conventional type of boiler and engine with their obviously inherent defects should have been so faithfully incorporated in its design. The fire-box, for instance, with its large flat surfaces, is necessarily uneconomical in the use of metal and needs an elaborate system of stays to give it the requisite strength, and, needless to say, this makes it a very expensive job. With regard to the engine, the lack of gearing frequently means that a much larger locomotive than would otherwise be necessary has to be used in order, say, to negotiate a stiff gradient in one part of the sidings. Other drawbacks which may be mentioned are the difficulties of cleaning the boiler, its extravagant use of fuel and water, and the waste incidental to lubricating the engine.

A new type of locomotive which is said to be free from these deficiences has been placed on the market by The "Sentinel" Waggon Works, Ltd. The locomotive represents a development of the well-known road wagon manufactured by this firm, and is fitted with the same type of boiler, engine and gearing. In order to form some idea of its capabilities under conditions resembling those at a colliery, at the Craig-yr-Hesg quarries at Pontypridd. These quarries, in which blue Pennant stone is being worked, after having been disused for eight years, are now being exploited by a contracting firm of Cardiff. Owing to their inaccessible position, it was impossible in the old days, before the locomotive was acquired, to send any of the stone away by rail, but a track has now been constructed connecting the workings to the Great Western Railway Company's main line between Cardiff and Merthyr Tydfil. As this track has an average gradient of 1 in 29, and the steepest portion of it—a length of 100 yards—has a gradient of 1 in 22, the conditions, so far as testing the capabilities of the locomotive are concerned, approach the ideal in severity. The connecting length of line is about three-quarters of a mile in length and is by no means free from curves, but the locomotive quickly demonstrated that it was able to pull a load of 40 tons uphill from a dead start on the spot where the gradient is steepest (1 in 22). Starting on the level it pulled with ease

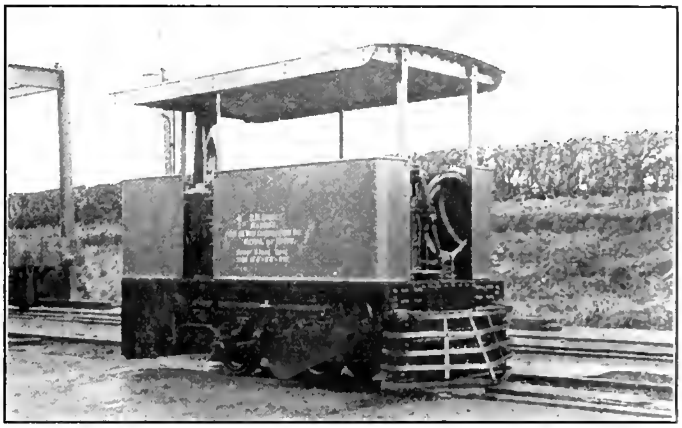


Fig. 3—80 H.P. "Sentinel" Locomotive in Service in India

a load of 76 tons, composed of trucks and stone. The entire cost per week, including wages, depreciation, repairs, fuel, lubricating oil, etc., is under 10 pounds per week (or about $50.00) when 700 tons are hauled. When the quarries are further developed these relative figures will show an even more favorable comparison.

Description of the Locomotive

The locomotive in use on this line weighs 20 tons and is geared for a normal maximum speed of 25 miles an hour, though other weights, it is understood, can be supplied. The ratio of the gearing can be adjusted to obtain maximum speeds of from 10 to 40 miles an hour. Fig. 4 is a sectional elevation and plan, and shows the general disposition of the boiler, engine, water tank, etc. It is at once obvious that the whole design is fundamentally different from that of the ordinary type of locomotive. In the latter the wheels, axles, and frame are commingled with the engine and arranged, as well as possible, around the boiler, thus making a congested and inaccessible whole. Fig. 4 shows, on the other hand, the locomotive under consideration to be constructed of entirely separate and self-contained units. The engine and boiler are quite distinct, and the position in which they are mounted on the frame gives remarkable accessibility. The frame itself is also self-contained and is solidly constructed of heavy steel channel sections. It carries the buffing gear and is supported by springs from the axles and wheels. This construction enables adjustments to be made on any of the separate units in a minimum of time, and, if necessary, a unit can be removed entirely and replaced by a spare.

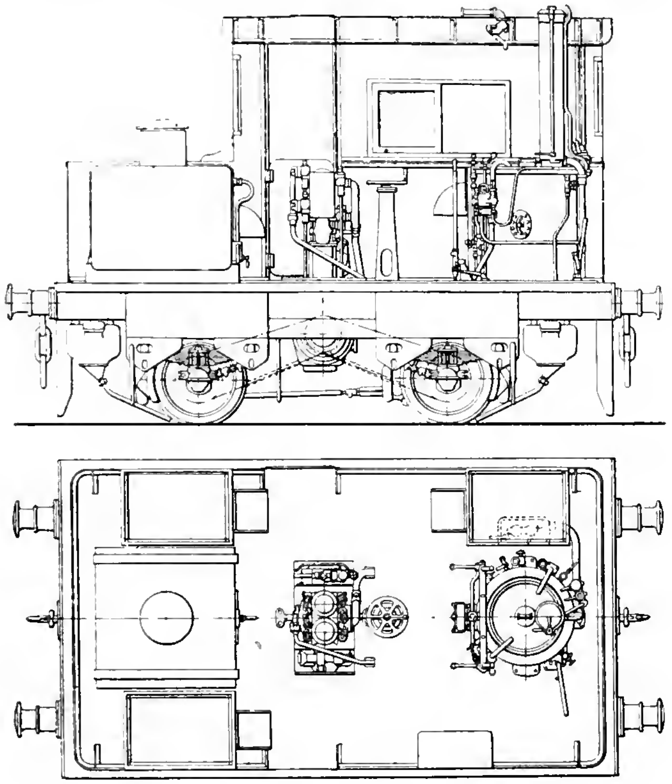


Fig. 4—Plan and Elevation o fthe Locomotive Showing Arrangement of Boiler and Driving Mechanism

In the main the design of the wheels, axles, axle-boxes, and springs, follow standard practice, but can be removed in about two hours, by simply jacking up the end of the locomotive and taking out a few bolts and pins. The wheels are rolled from steel and have treads which permit of 1¾-in. wear, and are then heavy enough to stand retyring. Springs and axles are of steel and are made of British Standard specification. Self-lubricating axle-boxes are provided, the bearing surfaces being oiled by pads from an oil bath. Leathers are fitted to exclude dust.

A chain drive transmits the power from the engine to the axles. Experience with road vehicles has established the success of this type of drive, and noteworthy advantages are secured by its introduction to locomotives. A suspension can be used, for instance, that is more flexible sideways than is permissible in the ordinary locomotive, where the connecting rod of the engine is direct-coupled to the wheels. Consequently, the blows imparted to the rails in curves are backed only by the weight of the axle and assembly, instead of by the whole mass of the locomotive. The destructive effects on both the locomotive and road are thus correspondingly reduced.

The Engine

It will be seen from Fig. 5, which gives sectional elevations of the engine, that the whole of the working parts are enclosed. This affords protection from dirt and the oil bath formed in the lower part of the crank-case ensures that the cranks, guides, etc., are perfectly lubricated. Doors are provided in the case at all points where it is desirable to make inspections and to render the various parts accessible for adjustment. The cylinders are 6¾ in. in diameter and have a stroke of 9 in. Steam is admitted and exhausted by poppet valves, operated from camshafts running in the crank-case oil bath. On these shafts are cut a series of cams, the central one giving a drain position, when steam may be blown through the engine to warm it up before starting. A movement endways to the full extent brings into operation the second pair of cams, which admits steam for 80 per cent of the stroke for starting in either direction. In the half-way positions steam is admitted for 30 per cent of the stroke for normal running. Double glands are fitted to the piston rod to prevent water from running into the crank-case oil bath.

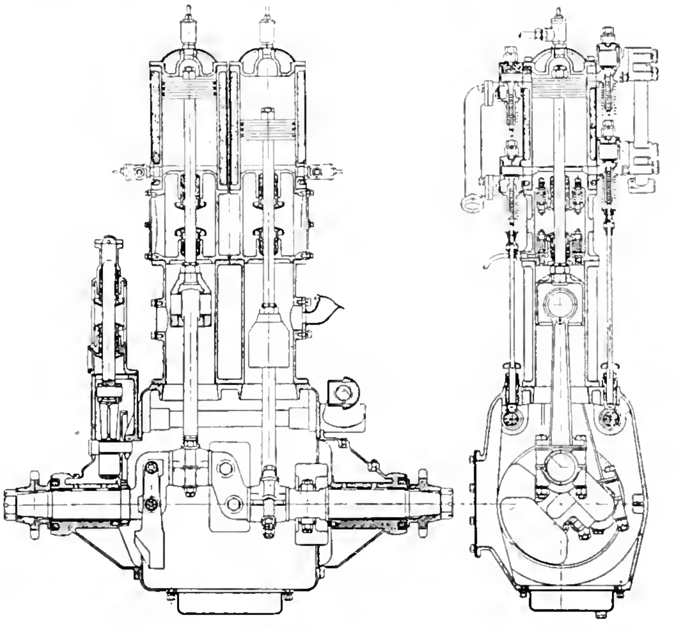


Fig. 5 Side and End Sectional Elevations of Enclosed Engine of "Sentinel" Locomotive

At the normal running speed of 500 r.p.m. the engine develops 100 b.h.p., and it is claimed, at this output, that the steam consumption is only 17 lb. per brake horsepower hour. The torque improves at the lower speeds, and when working on the starting cams the engine will give 80 b.h.p. at 150 r.p.m. These figures are certainly remarkable, as the ordinary small locomotive uses from 40 to 60 lb. of steam per brake horse-power hour.

Boiler and Its Accessories

The economics effected by the engine has enabled considerable modifications to be made in the design of the locomotive. The boiler, for instance, needs to be only a third of the size of that of the ordinary locomotive and this alone reduces the radiation losses and leads to further economies. Fig. 6 is a sectional elevation of the boiler giving the main dimensions. The design has been largely developed as a result of experience gained in road traction work where the conditions, so far as vibration and unskilled attention are concerned, are frequently of the worst. Thorough cleaning is easily and simply effected, the inner shell with the tubes being lowered by removing two rings of bolts. Every part of the surface, including the insides of the straight tubes, is thus fully accessible and can easily be cleaned. A complete new inner shell with the tubes fitted can be substituted in a few hours at a cost of less than 50 pound—a large saving over the cost of retubing an ordinary locomotive.

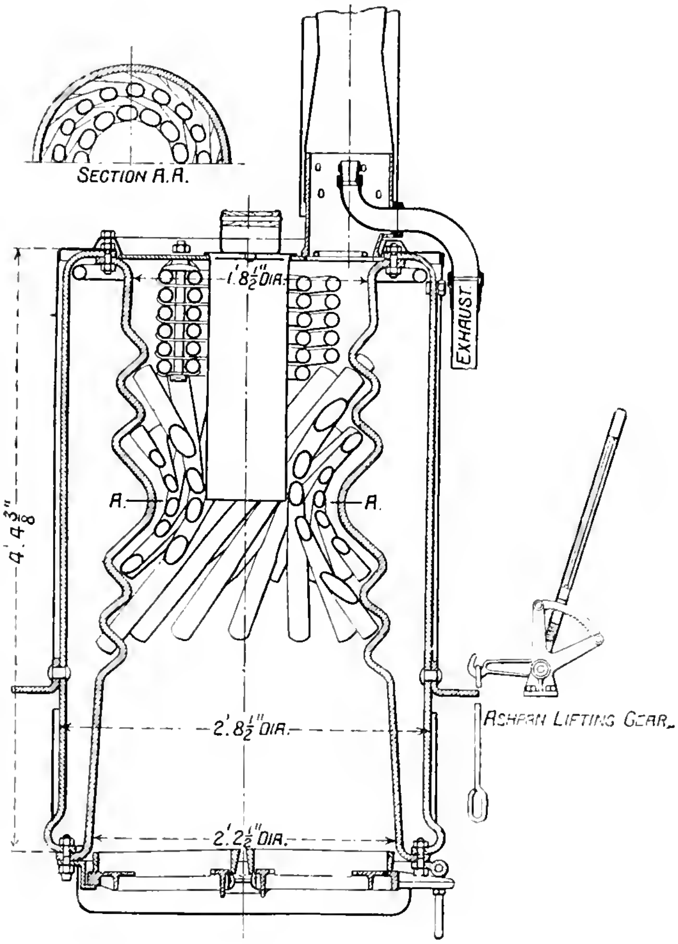


Fig. 6—Sectional Elevation of Boiler

With good coal the boiler is capable of producing 2,000 lb. of steam per hour at 275 lb. pressure. Steam can be raised in 45 minutes, which represents a large daily saving of time compared with the usual type of locomotive boiler. Mountings comprise a double safety valve, two water-level gauges, and stop and auxiliary valves which are fitted with renewable seats.

It will be seen by careful comparison that the design of the boiler does not permit of many defects of the ordinary type to occur. The tube ends are in the water and thus, not being exposed to the flame, they have little tendency to leak. There are neither stays, foundation rings, *fire-hole door*, internal regulators nor joints—all of which are weaknesses and a source of trouble in the usual type of locomotive boiler. Moreover, as the fire-box is cylindrical, it is impossible for buckling to take place, such as occurs in the flat plates of the conventional design. There are no mud plugs around which wasting is liable to occur. Leakage from the blowoff cock drops clear of the shell.

Some Other Points

There is ample space in the cab for the driver, who is afforded every protection from the weather. Look-out windows are provided in all sides. The controls are duplicated on either side so that the driver can manipulate whichever is most convenient for the supervision of the road. Stoking is accomplished with a minimum of effort, a few shovelfuls of coal dropped down the central chute every mile or so being all that is required. On an average 7 lbs. of coal is required per mile run, or, say, 5 to 8 cwts. for a day's switching. This figure is remarkable when compared with the 20 to 30 cwts. of coal required for the same duty by a locomotive of the usual type.

The brakes are operated either by hand or by steam. Being of cast iron, the blocks are easily and cheaply renewed.

Tests

It is found in practice that the even nature of the drive increases the drawbar pull in relation to the adhesive weight, and a much more favorable ratio is obtained than is ordinarily the case in any other locomotive. Starting efforts as high as 28 per cent of the adhesive weight have been obtained and steady pulls of 3½ tons have been registered with a 20-ton locomotive. Fig. 7 gives the results of a test conducted by the London & North Eastern Railway Company on a "Sentinel" locomotive. The load consisted of the dynamometer car, 24 wagons and a van—a total of 366 tons.

As above stated this new development in prime movers for railway use is employed as separate or individual locomotive unit, or as an integral part of a passenger motor car, which in England is termed Rail coach. The motive power or patent boiler and engine being fundamentally the same for each class of service. The details of the patent boiler and engine may be easily understood by reference to the following cuts.

Illustration Fig. 7 is a reproduction of record of Dynamometer car test of super Sentinel locomotive on London & North Eastern Railway. The chart it will be noted not only records boiler pressure, cut-off and tractive power developed, but actual running time between stations in seconds, total time on run, and average speed per hour.

It is of special interest to note that the train consisted of 24 wagons and van, or 24 freight cars and caboose as we would term it, weight 365 tons 18.18 c.w.t. or approximately 366 tons.

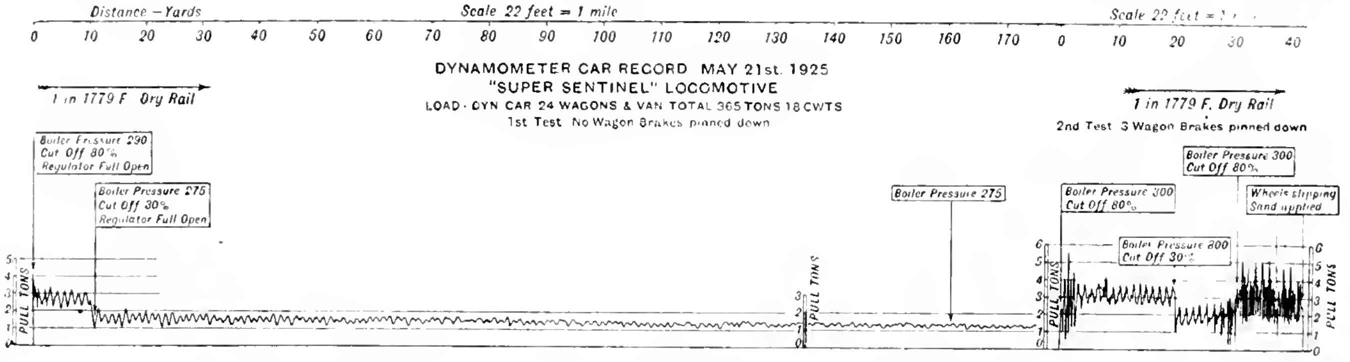
It is also very interesting to observe that as a result of four months' service or 120 days, 23,000 miles were made and that the overall working expenses were only 9 pence (or 18 cents in our money) per train mile, and that the operating radio was only 43 per cent. These Sentinel locomotives are made in three sizes.

Type B. E. 80 Horse Power
Type C. E. 100 Horse Power
Type D. E. 200 Horse Power

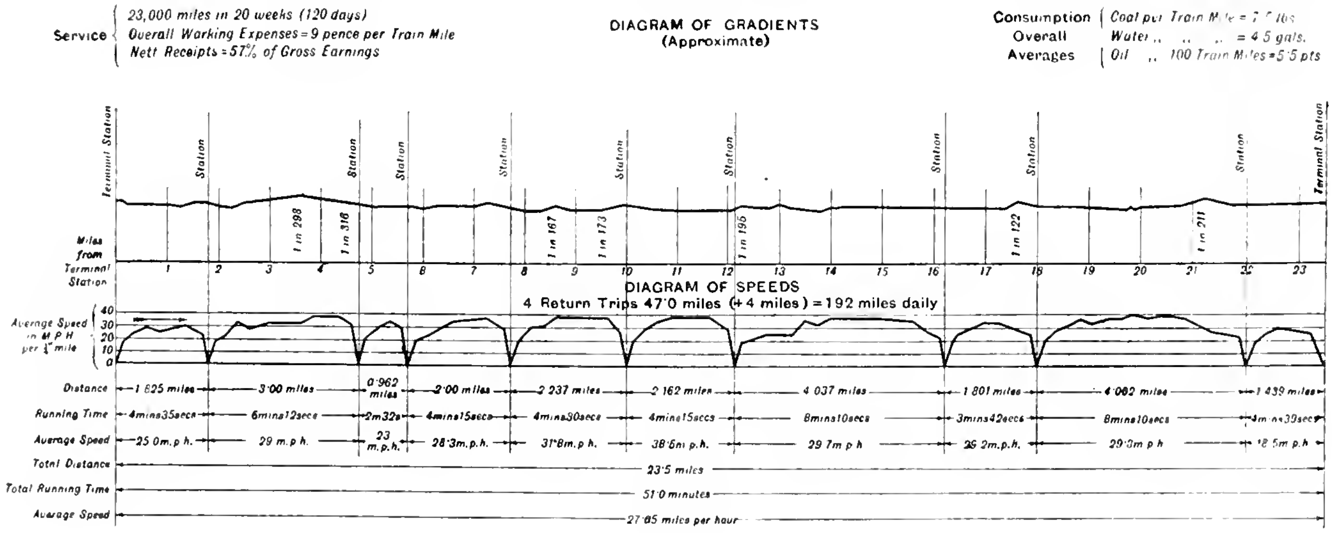
Sentinel locomotives for gauge of track from 2 ft. to 5 ft. 6 inches have been purchased by 44 companies in England, and 31 foreign companies or a total of 75 companies, many of these being railway companies, while the total number of units purchased is 148.

One railway company in Egypt in order to check the inroads on their passenger travel by cheap motor cars, bought a Sentinel locomotive and finding that, with the native labor there available they could operate a train at the astonishingly low cost of under four pence a mile (less than 8 cents in United States money) they speedily ordered twelve more, and with these practically all the lost passenger traffic was recovered, for even a "Tin Lizzie" cannot compete at such a price, and twenty-four more Sentinel locomotives were shipped out shortly after.

Results similar to the above have also been realized from the use of Sentinel locomotives on branch lines in freight service, while for switching work to which the type is especially adapted the economies are as great, if not greater.



Result of Tests of "Sentinel" Locomotive by the Derwent Valley Railway of the London & North Eastern



Gradient and Interstation Speed Diagram for Steam Rail Coaches on the London & North Eastern Railway

The following tabulated comparisons of cost to operate Sentinel locomotives as compared to conventional type of steam locomotives usually used in England in the same or similar service serve to emphasize the resulting economies in favor of the former.

	Sentinel Patent Switching Locomotive	Traditional Type Switching Locomotive
	£	£
Coal—75 tons at 30/	113	270
Wages—50 weeks at £3	150	200
Stores—Oil, etc.	50	100
Repairs and upkeep	50	300
Amortisation, 7½ per cent on £1,400	105	105
Annual Cost	£468	£975

Running costs of Sentinel locomotives, in pence per mile, when running 200 miles a day on 300 days a year.

Wages—Two Drivers and two Guards at 15/ a day each	3.6 d.
Coal. 12 lbs. per miles at 30/ per ton	1.92 d.
Stores, oil, etc., at £50 per annum	2 d.
Repairs, repainting, etc., at £50 per annum	2 d.
Amortisation, 6 per cent per annum on £1,200	29 d.
	0.21 d.
For use, cleaning and repair of coaches	1.79 d.
Total cost per mile run	8 pence

The cost of operating a Sentinel Locomotive 56-Passenger Coach:

	Per Day	Per Year	Per Mile Run
Wages	52/	780	3/12 d.
Coal	21/8	325	1,30 d.
Stores, oil, etc	5/	75	0/30 d.
Repairs, repainting, etc.	8/	120	0/48 d.
Amortisation	15/6	233	0'93 d.
	£5/2/2	£1.533	6 13 d.

The above figures covering the cost of maintenance and operation of the Sentinel Locomotive are given in the British monetary system. The £ Sterling equals $4.84. One d or pence is equal to approximately two cents.

Sentinel locomotives or rail coaches for passenger service are now in operation in eighteen different countries. In some places they have been in service as much as three years, giving highly satisfactory results.

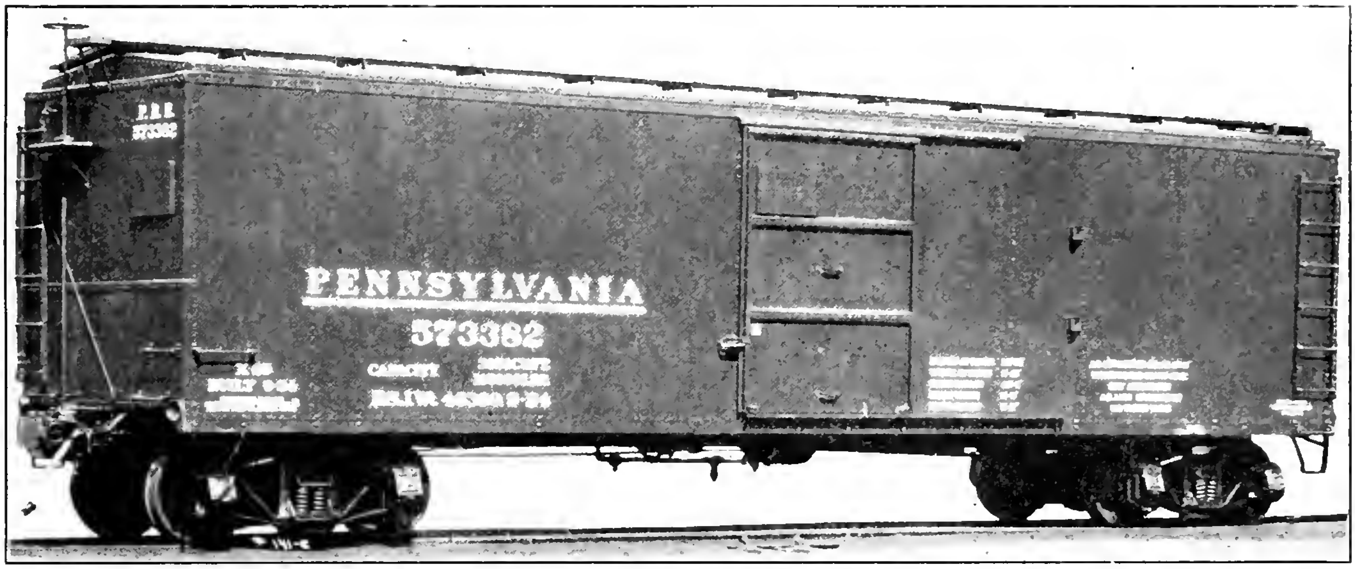
While great credit is due American railway engineers for the wonderful progress made in the development of the motor car for branch lines and short run service which has contributed in no small degree to more economical operation, yet it would appear from the above that our English cousins have not only kept pace in this respect, but that for an engine design especially adapted to certain kinds of service, the Sentinel locomotive stands in a class by itself.

Mass Production of Freight Cars

By George A. Richardson

Ninety years ago, or to be exact, in 1835, three ambitious young men made an extensive and exhaustive investigation of the methods then used by manufacturers of stage and railway coaches throughout the new England section. Railroads still were a new though promising possibility. They found that most of the shops were merely frame sheds in which the rough, old-fashioned four-wheel cars were being constructed.

As might be surmised, all three young men were of a progressive turn of mind. They believed there was room for marked improvement in the more or less primitive methods of building the equipment, as well as in the arrangement of the plant required. Two of the young men, Mahlon Betts and Samuel N. Pusey, formed a partnership for the purpose of building railroad cars. This was in 1836. Erection was begun on a three-story brick building at the corner of Front and Tatnall streets, Wilmington, Del., and production soon started. A year later Samuel Harlan, Jr., who had been the third member of the investigating party, was taken into partnership.



All Steel Double Sheathed Box Car Built for the Pennsylvania Railroad Co. by the Bethlehem Steel Co.

From these early pioneer days to the present, as a result of rapid increase in tonnage and the consequent problems confronting the railroads, the change in type and capacity of equipment has been going on continuously and even at the present much is being done in the way of simplification, efficiency and increased carrying capacity of the equipment.

In recent years the interchange of ideas and standardization of equipment has helped very materially the production of cars suitable for general use. Many firms have entered into the manufacture of railway equipment. These manufacturing plants have grown to immense proportions capable of handling the business with a high degree of efficiency. With large organizations of highly trained men and special machinery they are producing this equipment under keenly competitive conditions which result in low prices. The day of the small producer has passed. Unit production, by necessity, has given way to mass production, and this is particularly true in case of freight cars. As a matter of fact we find it is desirable to segregate passenger car work because of its highly specialized character and demands for finish, which call for a great amount of time. Hence we find that the old firm of Betts, Pusey and Harlan, which, after passing through several changes in organization in the course of the years, finally being acquired by the Bethlehem Shipbuilding Corp. in 1911, came gradually to specialize on passenger car building, and still continues to do so.

About 25 years ago the Cambria car shops at Johnstown, now operated by the Bethlehem Steel Co., and which like the shipbuilding corporation are a subsidiary of the Bethlehem Steel Corporation, were started. Today we find them to be an excellent example of the very antithesis of the little shop founded by Betts, Pusey and Harlan almost a century ago.

The freight car is one of the big factors in railway transportation, and it is in the building of this equipment, the problem of mass production is the most important. The present generation remembers 20- and 30-ton capacity cars, and the rapid change from those to the present types of 50-, 70- and even 100- and 105-ton capacity in some cases. Notwithstanding this great increase in car capacity, the total number in service has increased very much more rapidly.

The tremendous demand for freight cars that exists today and the radical changes in the methods of building them have completely revolutionized the methods of manufacture. Larger and more intricate and expensive equipment has called for bigger manufacturing organizations. There are many freight car shops now in the country capable of taking care of any ordinary demand placed upon them, and some half dozen are equipped to perform any class of freight car building with efficiency and dispatch. The Cambria car shops are an excellent example of this latter type.

Started about 25 years ago, the productive capacity of the Cambria shops has increased until today nearly 100 cars of various kinds can be built every 24-hour day. Originally the work was confined to steel cars of certain types, but with the changes in capacity provision has been made to handle any type of car for freight service whether all-steel, wood or composite. Low cost is a result of masproduction. Most persons are familiar with the production methods in the automobile and similar industries but do not consider the building of freight cars a problem of mass production. It is a matter of fact, however, that methods prevail in the building of freight cars identical with those in the manufacture of automobiles, modified only to meet local conditions.

The car builder has a more difficult problem than the automobile builder, in that he must not only maintain his production at low costs, but his work is not confined to any one or two types of cars month in and month out. His problem is best likened to that of the fictitious case of an automobile builder who, while adhering to present mass production methods would at the same time have to be prepared to build a low priced automobile today, a middle class one tomorrow, and one of a higher grade at a later date. All these problems must be met and solved without changing the flow of production, a thing which is practicable, because the ability to shift has been taken into consideration. The equipment provided must be of as nearly a universal type as possible.

Proper facilities for the storage of materials are important. The flow of materials must follow the same channel regardless of the type of car being built. The endeavor of a large production organization giving its time and energy to the single purpose of freight car production can be likened to an automatic machine in which each movement follows the preceding one with regularity and exactness. Starting with immense stores of raw materials, many hands and numerous machines transform the inert masses into a symmetrical and useful commodity.

In the modern car shop one witnesses a feat which is impressive. One sees the various parts moving rapidly together and combining with the regularity of clock work into one whole in a length of time almost inconceivably short. Imagine, for a moment, that in the Cambria car shops one freight car is completed every 15 minutes during the working day, and that this rate is kept up day in and day out during the entire time the current order lasts. It is fascinating to see the various parts going together and moving from position to position. Starting at the very beginning the immense piles of raw materials are transformed into trucks, under-frames, bodies and complete cars with a dispatch that would have seemed marvelous 20 years ago. The rapidity is due to a complete and careful subdivision of work into position operations and the concentration of the maximum amount of labor that can be used most economically in every position. Often 1,000 men are employed in the ewo erection shops at Cambria.

Recently, the Bethlehem Steel Co. completed a very interesting car building job, which is an excellent example of mass production methods on a large scale. The particular car in question was a steel box car with inside wooden lining, for the Pennsylvania Railroad. The construction of this car marked a big departure at the Cambria shops, for it had long been a policy to restrict operations to all-steel cars only. At the same time it was an excellent example of the adaptability of the plant and working force because it meant the building up of a complete woodworking shop force on short notice, and the results obtained were successful in every way.

The actual work of erection was divided between two shops. The steel body was erected and placed on the trucks in the steel erection shop and then the lining was applied in another shop. In order to show what was done, it is necessary to start at the beginning, trace the flow of material, and note the various steps of fabricating and assembling.

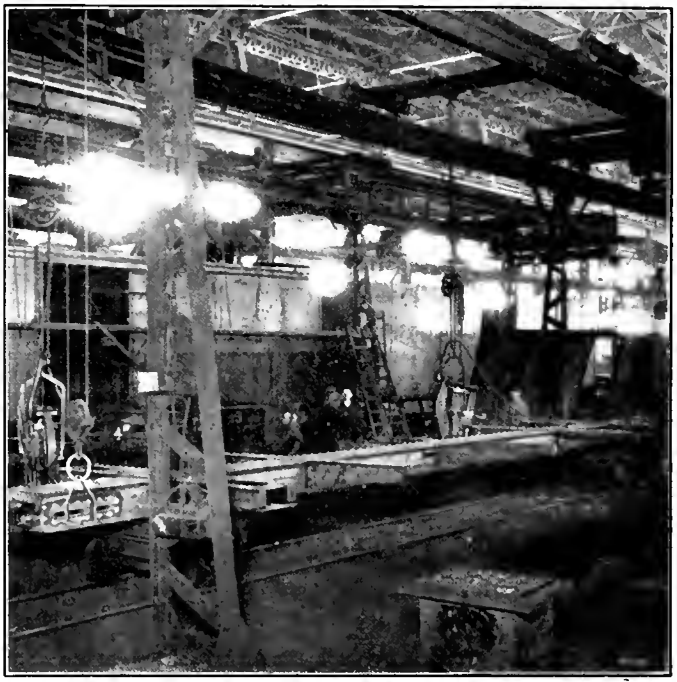
(1) Wheels and axles which have been mounted in the mounting press are deposited on the trucking track. From this position they are allowed to roll down the inclined grade by gravity to the truck assembly positions.

(2) The next operation consists in placing the side frames on each two pairs of wheels and inserting bolster and spring plank.

(3) Springs are inserted under the bolsters, and journal boxes, bearings, wedges, and packing applied.

(4) Brake beams and shoes are applied. All parts are tightened up and the trucks are discharged to the car shop.

While this work is going on the cars are being erected as rapidly as possible in the erecting shop. Two sets of erection tracks are used in the steel shop, so that two cars are being built simultaneously. The cars are moved up one track and down the next so that the complete body is built in 12 positions. It is then so located that it can be lifted by a crane to a trucking track where it is placed on the trucks. The routine of assembly is as follows:



Method of Riveting of Underframe in the Building of Pennsylvania Box Cars in the Cambria Shops of the Bethlehem Steel Co.

Position 1.—Units for center sill assembly are brought together here and riveted.

Position 2.—Center sill is assembled and mounted on building trucks.

Position 3.—Crossbearers, bolsters and end sill diagonal braces are applied.

Position 4.—Riveting position. Above parts riveted.

Position 5.—Draft gear, couplers, and miscellaneous parts of underframe applied.

Position 6.—Riveting position. All turnover position. Underframe is turned over in order to complete riveting of all of the assembled parts.

Position 7.—Ends and sides assembled. Door jig applied. Body squared up.

Position 8.—Application of roof.

Position 9.—Riveting position.

Position 10.—Riveting position.

Position 11.—Doors applied.

Position 12.—O. K. positions. In this position all work is carefully inspected, defective rivets replaced and such other corrections made as may seem necessary. Body is carried by crane from here to the trucking track.

Positions 13 and 14.—Trucking track. Body placed on trucks, electric welding, air brake applied and inspection of air brake.

The car is thoroughly cleaned by washing. A first coat of paint is given inside and out. This includes roof and the spraying of the trucks. The body is then ready for the wood application, which in the present case consists of a wood floor and single lining, extending to the top of the car. This is done in the wood erecting shop where wood working machines prepare the lumber. All parts to be applied to the car are made in the shop including running boards and card boards. These all receive a first coat before being applied to the car.

Here again position work is an important factor in securing production. The cars are brought from the steel shop and enter the wood erecting shop at the lower end. The cars are moved forwards from position to position as follows:

Position 1.—Lay flooring. This is more difficult in the present car than normally would be the case, on account of the necessity of having to cut and trim around the posts in order to make a tight joint. One of the outstanding features of the handling of this job in the Cambria shops is the care taken to get an absolutely tight floor. About every four feet the boards are wedged into place and held by bolting down one board. The first gang of men lays the floor as far as to the door posts.

Position 2.—Continuation of floor laying. Threshold or door opening boards placed. This work is performed by a second gang which follows right on the heels of the first. This gang lays the boards in place and wedges them apart in the center. The loose boards on both sides are cleated temporarily and the resulting gap is measured. A board is then planed to a width about $\frac{1}{8}$-in. wider than the width of the gap. The wedges are removed. The two cleated groups of boards are lifted to a pyramidal position, the key board inserted, and then, with the aid of large levers the flooring is forced into place. In this way a tight fit is obtained.

Position 3.—Laying out floor for drilling for floor bolts. This is done by a lay-out boy with the aid of templets.

Position 4.—Drilling holes for floor bolts. Two drillers with electrically driven drills do this job.

Position 5.—Placing and tightening up floor bolts. After the holes have been drilled, two men apply the bolts. At the same time a gang underneath the car is applying the nuts and screwing them tight.

Position 6.—Grain sealing. This is done to prevent any possibility of grain leaks. A worker pours a hot asphaltum base sealing compound all around the edges of the flooring. He is followed by another man with a hot calking tool which is used to push the excess compound back into place. This is done with a special tool provided with a light and an electric heating coil, which heats the compound to the desired temperature. The tool was developed in the Cambria shops and Bethlehem is probably the only concern in the country using a tool of this kind.

Position 7.—Apply posts. This job consists in applying the side posts and bolting them up. The gang, consisting of 6 men, applies over 600 posts in ten hours or in other words an average of more than post a minute.

Position 8.—Side lining boards and end lining boards. are applied and wedged into place. Nailers follow and nail the boards.

Position 9.—Door post facers apply the posts and bolt them in place.

Position 10.—Cleaning and inspecting. Car is swept out and company inspector goes over whole job carefully.

While this work has been going on inside the car, the running boards, and card boards have been applied to the outside. It should also be borne in mind that while all work is inspected by shop's inspector it is also constantly being inspected by railroad company's representative. From the wood erecting shop, the cars are transferred to the paint shop where they receive a second coat of paint. Thy are stenciled again, offered for inspection for the railroad inspectors, given an air brake test and finally shipped out. While position work is a large factor in speeding up mass production, it should be borne in mind that the secret of the uniform and rapid rate of production obtained at Cambria shops without sacrificing quality is in some measure due to the use of jigs and templates. One will find an extensive use of jigs in the manufacture of roofs, doors, bolsters, running boards and of other parts, so that every part fits corresponding parts without any time being lost in fitting and adjusting. Even the quarter sections of the sides are jigged.

As an example of the methods used in assembling one of the smaller parts, let us take the running boards. Here we have an example of workmanship that is at once rapid and at the same time performed more thoroughly than often is the case. A special jig is used. The following are the steps performed in the assembling of the running boards:

Third Position in the Erection of Pennsylvania Box Cars in the Cambria Shops of the Bethlehem Steel Co. Showing the Underframe Ready to Be Riveted

(1) Angle bars placed on jig.

(2) Boards given first coat of paint before applying to jig.

(3) Boards laid out for drilling and boring.

(4) Boards bored and drilled on jig.

(5) Bolts applied.

(6) Screws applied at ends with electric driving machines. This operation calls for special emphasis because of the fact that it is often the practice to drive screws with a hammer.

(7) Completed running board lifted off jig and given second coat of paint on floor.

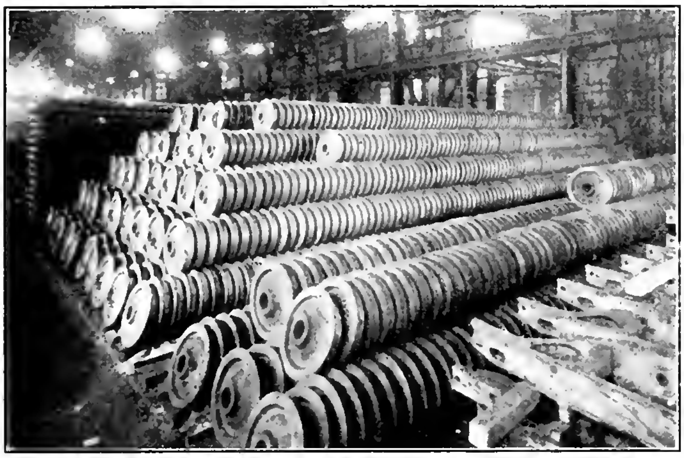
(8) Running board lifted into place on top of car and fastened.

Another fact which makes for large production and at the same time makes it possible to make a product of the high grade, is the extensive use of gauge and multiple punches. Unquestionably the dominant fact which remains in one's mind is that mass production of this kind, production where accuracy of workmanship, speed, and minimum cost are all considered, cannot be obtained by an organization that is not keyed up and specializing all the time on this class of work.

I have certainly enjoyed the privilege of being here. I realize there are some here that know more than I do about car building. At the same time I do trust that some of you have learned something at least that you did not know about operations of this character.

The Bethlehem Car Shops

The Cambria car shops of the Bethlehem Steel Co., are given over entirely to the building of all kinds of cars for freight service. Passenger cars are built in the Harlan plant of the Bethlehem Shipbuilding Corporation at Wilmington, Del. The complete segregation of this work is warranted for a number of reasons, one of which is that the building of freight cars is largely a production proposition whereas that of passenger cars calls for extraordinary workmanship for the high degree of finish and furnishings and is therefore considered a specialty business.



Heavy I Beams Are Used for Foundation for Storing Freight Car Wheels

At the time when the Bethlehem Steel Co. took over the Cambria works of the Midvale Steel & Ordnance Co., the car shop units had been operating successfully for nearly a quarter of a century and had enjoyed an excellent reputation for the quality of their products. It was soon found, however, that there was much room for improvements and that a more efficient degree of operation could be obtained. Changes in layout and methods therefore were immediately authorized. In the two years, practically all of the changes and improvements had been completed very successfully so that production was increased nearly 100 per cent and a better quality of cars have been turned out than ever before.

The reason for these splendid results can not be placed to any one thing. They are the outcome of a well thought out systematic and scientific plan of action in which numberless striking changes in methods have been introduced.

The axle finishing and truck building departments are important divisions in a car building plant. These departments produce essential units which, together with parts from other sources, converge to a common center where the cars are erected.

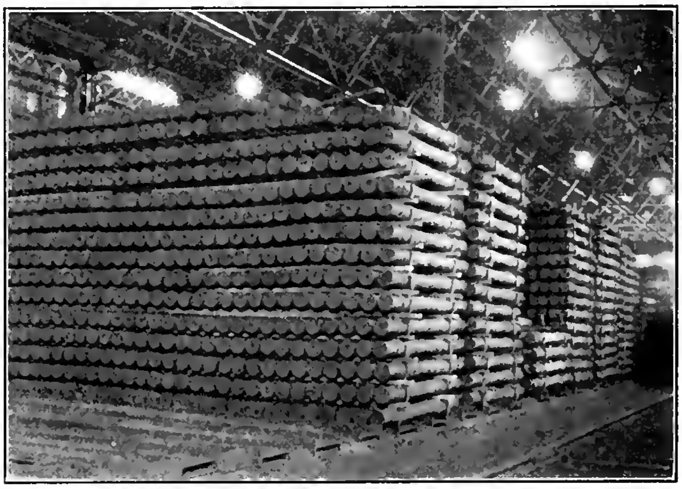
One of the outstanding features that impresses the visitor to the Bethlehem shops is the housing of these departments and particularly the storage of the various parts used by them of which we mention axles, side frames, bolsters, etc. All this material is placed under cover. The housing consists of a modern steel and brick building 90 ft. wide by 740 ft. long which affords ample space for the storage of all parts and of all machines entering into the manufacturing of the trucks.

Approximately one-half of the total area of the building is given over entirely for storage purposes. A standard gauge track extends the entire length of the building and has a capacity of 15 freight cars at one time. Three 10-ton overhead traveling cranes provide the necessary facilities for unloading material directly from the cars to the stock piles without rehandling.

Another thing which arouses the admiration of the visitor is the safe and orderly way in which all the various parts are piled. The storage space is equipped with beds made from heavy I-beams set in the floor. These steel beams afford a suitable foundation for storing heavy material. Twenty-inch I-beams are used. It has been found that these beams will just fit a 33-inch freight car wheel when the wheels are piled within the flanges of these beams. This method of piling guarantees the alignment and stability of the wheel piles and at the same time makes it possible to build up very high piles, thus giving a large storage capacity with minimum use of floor space.

The beam beds also afford an excellent foundation for the piling of axles, side frames, truck bolsters and other material entering into truck construction. When axles are being stacked hardwood stringers are inserted between each layer, with bent steel flats placed at the end of the piles thus allowing each layer of axles to be of the same length. This method prevents the slipping or rolling of the axles and allows them to be piled high with absolute safety even though the ends of the piles are vertical, as can be seen in the accompanying illustrations. Wood stringers are also used in the piling of side frames, bolsters, etc., as a regular practice in order to make the piles safe. As an additional precaution a slight camber is given to the piles by the proper placing of the stringers.

As a result, one will find an unusually orderly appearing storage layout not at the expense of, but in conjunction with the very decided advantages of increased safety. Greater storage capacity has been provided. Another feature which has not yet been mentioned is the ease of taking inventory. Passage ways are provided between the various piles and this makes it possible to take inventory very rapidly and accurately.



Method of Piling Axles in the Cambria Shops of the Bethlehem Steel Co.

The axle turning department is provided with 12 modern axle finishing lathes. As the axles are finished they are transferred directly from the machines to another storage bed at the head end of the lathes by the same hoist. Here the axles are inspected, gauged and rolled to the end of the bed where the wheels are loose-mounted on the axles by means of monorail and suitable hoist. The assembled wheels and axles are then rolled from this position on steel floor plates of suitable width to a 600-

ton mounting press. After the final mounting they are rolled to the end of the truck building bed where they are picked up by means of a small hoist and deposited on rails for the final truck assembly.

An important aid in securing production in cold weather is the provision of ample heating facilities which are particularly necessary on account of wet cutting. The indoor storage of the axles and other parts is also a very decided advantage during the winter months. It is a further source of saving in time because the workers do not have to contend with the parts being covered with ice and snow, which would be the case when outdoor storage is used.

The car wheels are deposited on a wood floor close to the wheel boring machines in lifts of eight wheels. These lifts are made possible by the use of a high carbon steel bar which is inserted in the bore of the wheels and carried by a double ring chain suspended from the crane. They are placed at the machines by wheel rollers in the usual manner. After the boring the wheels are set up in rows where they are gauged and marked.

The wheels are selected from these rows in accordance with the gauge number marks. They are rolled to the end of the axle finishing bed where they are loose-mounted on the axles as described above.

The truck building bed is mounted on a cement foundation with heavy I-beams supporting the rails. The top of the rail is approximately 17 in. above the floor line, which affords a comfortable height for the truck builders. The bed is built on a one-half of one per cent grade which permits of an easy movement of mounted wheels and trucks. At the end nearest the wheel mounting press double rails are provided, which permit the overlapping of the mounted wheels, thus giving greater capacity per unit of length. As the mounted wheels approach the point where the truck building begins, these double rails converge to a single rail system by means of an automatic switch.

Side frames, spring planks, bolster, etc., are assembled on beds adjacent to the building track and the completed truck frames, which can be considered as a sub-assembly, are then swung onto the building bed by means of overhead jib cranes and electric hoists. On the building bed the trucks are assembled and fitted under a position system, constantly approaching the exit where, after the journals have been packed and the trucks inspected, they leave the building bed on a sharp incline and roll by gravity to the car erecting shop.

In addition to the facilities which have been mentioned here, there is the usual complement of air, gas and oil lines, heating furnaces, electric power, hoists, drill presses, etc., necessary to perform the work with economy and dispatch. The way each action fits into the general scheme of things is most impressive.

On leaving these departments one impression that will stay with the visitor is the neat and orderly handling of material and its uniform flow without backward movement. Every facility provides rapid and economic handling of each operation from the time the miscellaneous parts are unloaded in the shop until the finished trucks leave the department. The great aim has been to secure smooth and uninterrupted production at maximum capacity and the results obtained in these two departments alone tell their own story.

Air Brake Men Hold Interesting Convention

Thirty-fourth Annual Meeting Held in Washington, D. C., Largest in History of Association.

The thirty-fourth annual convention of the Air Brake Association, held at the Mayflower Hotel, Washington, D. C., May 24 to 26 inclusive, was the largest and most successful of any meeting of this organization. Between 1,100 and 1,200 members, guests, and representatives of supply manufacturers were present to hear and discuss the many interesting papers presented on subjects covering air brake matters. In addition, some eighty supply companies provided extensive display of their products.

The convention was called to order by the president, M. S. Belk, general air brake instructor, Southern Railway, and addressed by Frank McManamy of the Interstate Commerce Commission, and by R. H. Aishton, president of the American Railway Association. An interesting report on air brakes and foundation gear for gas rail cars was presented by the Central Air Brake Club of which the following is an abstract:

Air Brakes and Foundation Gear for Gas Rail Cars

The present gas rail and gas electric motor cars are very closely similar in their details of construction and operation to standard traction or electric railway units in service today. The gas electric truck is a traction truck, and although in the gas rail truck the motors are replaced by the differential and drive shaft, the fundamental controlling factors acutally put this truck in the traction class, especially the power truck. For these reasons, these cars have been braked in accordance with traction standards; that is 100 per cent brake ratio based on 50 pounds cylinder pressure.

Motor car trains with a standard passenger coach as trailer will, therefore, have a more effective brake on the motor car than on the trailer, in the ratio of 100 to 75 for a full service application. The slack action in a two-car train under these conditions was thought would not be noticeable, and the tendency would be to keep the slack in during a brake operation. One reason for using a higher ratio for these units than the steam road passenger ratio of 90 per cent on 60 pounds is that considerably shorter stops could be secured with a higher ratio, with which there is greater protection against wheel sliding than on standard passenger cars, for the brake control is much more flexible. Due to the fact that feed valve pressure is available with a straight air application, restricted slightly, however, by the spring in the double check valve, the full straight air service brake ratio is 135 per cent approximately. The high emergency feature of the triple valve also provides for 135 per cent approximate brake ratio in emergency.

The short wheel base of these trucks requires the use of the single shoe type of brake rigging, and on account of the installation of drive shaft and differential on the gas rail trucks and the motor on the gas electric trucks, the truck levers should be located between the wheel treads and connected to the pull rod through the medium of an equalizer bar. Because the shoes must be considerably below the wheel centers to prevent journal displacement and tilting, and to allow for rail clearance of the bottom rod, truck ratios should be comparatively high, and the total possible travel of the live truck lever is limited so that on most trucks that is the primary point of brake rigging fouling with excessive shoe wear. With these limitations, therefore, is it obvious that a brake rigging with a nominal initial brake cylinder piston travel of approximately 5 in. will permit of a greater linear shoe wear than a similar rigging with 8 in. initial travel; i.e., with 5 in. initial piston travel the car can make greater mileage between bottom rod slack adjustment take up periods than with 8 in. initial piston travel.

For these reasons the traction standard of 5 in. nominal piston travel should be adopted for these equipments and auxiliary and supplementary reservoirs should be accordingly reduced in size so that full equalization only will be obtained with a 20-pound reduction off of 70-pound brake pipe with a brake cylinder travel at 5 in. Gas rail and gas electric brake equipments should, therefore, have auxiliary and supplementary reservoirs of smaller size than has previously been standard for steam road service where the piston travel has been based on 8 in.

Recommended practice for the total maximum leverage ratio on steam road passenger cars varies from 9 to 1 with 8 in. and 10 in. equipment to 5½ to 1 with the double 18 in. Traction car recommendation, however, permit the use of a 12 to 1 total leverage ratio, though 10 to 1 is acceptable as a maximum where it is feasible for the particular car design under consideration. Account of the traction characteristics of these trucks, the recommendations are for the traction standards, i.e., with a maximum total leverage ratio of 12 to 1. This recommendation is logical and based on engineering requirements.

With any car having this type truck, with a fixed truck ratio, where the travel of the top of the live lever is the limit of the brake effectiveness, it is obvious that the total leverage ratio of 12 to 1 will not permit as great a car mileage between bottom rod slack adjustment periods as would a lower total leverage ratio. In explanation we might add that with a fixed truck ratio, the higher the total leverage ratio, the higher will be the cylinder leverage ratio, therefore, with 5 in. initial piston travel the high cylinder leverage ratio will provide greater remaining live lever travel available for shoe wear.

The brake rigging for these gas rail and gas electric cars should be designed in accordance with the A. R. A. stress limitations which are briefly as follows for wrought iron and mild steel:

Maximum recommended stress for pins in double shear, 10,000 pounds per sq. in. Maximum recommended stress for struts or compression rods, 15,000 pounds per sq. in. Maximum recommended bending stress in levers and beams, 25,000 pounds per sq. in. Maximum recommended stress in rods intension, 15,000 pounds per sq. in.

When it is found desirable to use high carbon or alloy steel for the foundation brake details, higher maximum stresses are, of course, permissible.

It is recommended to adjust brake shoes with ⅛ in. clearance.

Brakes will be set with a movement of from 2 to 2½ in. at the top of the live lever, giving a 4 to 5 in. piston travel. Total travel of the live lever is ordinarily limited to 5 in. which gives from ½ to ¾ in. shoe wear. The levers should be connected at the upper end with an equalizing bar, which insures even pressure being applied to each side of the truck.

Probably one of the first things that will attract the Steam Road Brake Expert's attention will be the slender construction of the brake parts. This is largely due to the use of special materials.

It should be practice to use S. A. E. 1035 Specification steel for levers and equalizers. After these parts are forged they should be annealed. This steel has a tensile strength of from 75,000 to 80,000 pounds with an elastic limit of from 40,000 to 45,000 pounds.

In order to reduce weight, advantage should be taken of the increased strength and stiffness of this steel, so that brake beams, equalizers and levers can be figured with a 23-000-pound fibre stress with service application of brakes. With emergency application the fiber stress will, of course, be increased. In comparing this practice with standard A.R.A. practice, using ordinary steels of from 55,000 to 60,000 tensile and elastic limits from 27,000 to 30,000 pounds per square inch, being worked at a fiber stress of 23,000 pounds, as compared with a steel having an elastic limit of 40,000 pounds, with ordinary working load of 23,000 pounds fiber stress, and in an emergency application of 13.5 per cent of the normal, the fibre stress would be 31,000 pounds.

It is readily seen by comparison that the maximum fiber stress is proportionately the same in these standard materials.

23000 : 30000
31000 : 40000

In case of accident, it will hardly be necessary to replace the brake parts from standard stock, as their position in the truck almost precludes their being damaged. If they should become distorted, it will only be necessary to reshape them and after the forging operation is completed bring them to a dull cherry heat and allow them to cool slowly in a furnace.

As to the necessity of replacing them on account of wear, all the holes should be fitted with case hardened bushings and the pins should be case hardened. It would, therefore, only be necessary to replace worn bushings, as the life of the parts would be indefinite.

The entire equipment, body, trucks, brakes, etc., should be laid out to give the maximum strength for the weights allowed for this class of car.

The above represents the conditions under which gas rail cars have previously been constructed, but as some of these conditions are not in accord with the standard steam road recommendations your committee submits the following for your approval:

Trucks and car bodies should be so designed as to permit full piston travel without interference of any of the parts and permit the use of total lever ratio as recommended for standard steam road passenger cars.

Where compressors of the electric drive type are used they should be controlled by a pneumatic device that will control them within a definite range of not to exceed 10 pounds variation.

Mechanical driven compressors should be equipped with a pneumatically-operated device restricting further compression when the maximum pressure is obtained.

Compressors of the following capacity are recommended:

For the motor unit not less than 16 cubic feet per minute and an additional 10 cubic feet for each trailer anticipated.

All compressors should be equipped with a device between the strainer and compressor to prevent freezing.

Main reservoir capacity to be not less than 10,800 cu. in. for 10-in. cylinder, and when additional reservoir capacity is desirable, two or more reservoirs should be used and the additional reservoirs should be separated from the first by a "parasite" governor.

Main reservoirs must be equipped with a safety valve that will open at not to exceed 10 pounds working pressure.

All piping of motor cars to be of wrought iron or copper.

All brake valves to be of the rotary type with an equalizing piston. Straight air and automatic features integral.

A feed valve located in the main reservoir supply pipe between the main reservoir and brake valve at a point convenient to the engineer. This to reduce main reservoir pressure to that of brake pipe.

Gages located at a point convenient to the engineer from his usual position in the cab, indicating main reservoir, equalizing reservoir, brake pipe and brake cylinder pressures. A feed valve and non-return check to be located in the straight air pipe below the brake valve and above the straight air cut-out cock, so that the straight air pressure may be reduced to a nominal force when used.

A cut-out cock to be located in the brake pipe below the brake valve at a point convenient to the engineer. This to be closed when the car is being handled dead in a train.

A double check valve as previously mentioned, known as the No. 14 double check, to be located at a point convenient for inspection and repairs, between the brake valve, triple valve, auxiliary reservoir and the brake cylinder.

Where double end control is desired duplicate equipment 'should be supplied each end of the car and the straight air pipes should be equipped with a double throw check valve at their junction with the pipe leading to the No. 14 double check valve.

The triple valve should be of the quick service, quick recharge, high emergency cylinder pressure and graduated release type, with a supplementary and auxiliary reservoir of proper size to produce a braking ratio of 80 per cent on 50 pounds cylinder pressure.

To safeguard against total loss of brakes in case of top or truck rod failure on either end of the car, it would be our recommendation that cars of this type be fitted with two brake cylinders braking each truck independently. The hand brake to work on both trucks and in harmony with the power brakes.

Wireless for Trains

A brakeman sitting in a caboose of a freight train and an engineer in the cab of a locomotive a mile and a quarter down the track talked to one another by radio at Schenectady, N. Y., recently as easily as two persons would carry on a conversation by ordinary telephone. The tests were made by engineers of the General Electric Company. Transmission was on a short wave length and low power, to avoid interference with broadcast reception.

Caboose and engine carried indentical apparatus—a transmitter and a receiver. Both locomotive and caboose were equipped with a double antenna, one for transmitting and the other for receiving. Communication was established at either end of the train by the simple act of removing a receiver and pressing a button. The pressure of the button called the other station by causing a howling sound in the reproducer or loud speaker at the receiving end.

The test demonstrated that communication may be carried on with comparative ease on a moving train. Radio communication, according to railroad men, will be most valuable particularly on trains consisting of 70 to 125 cars. On such trains the engineer and conductor are separated by nearly a mile of cars and there is no positive means of communication between them. Signals are usually exchanged by means of whistle or flare lights, which often fail due to curvature of the tracks or weather conditions. Should a defect develop on these long trains the conductor must either send a brakeman over the top of the train or stop the train by operating the conductor-valve, either of which would cause a delay.

Radio communication as provided by these sets give a positive means of instant communication and will materially expedite train movement on main lines as well as in the yards.

A sufficient number of sets have been constructed to permit road demonstrations of communication between the engine and caboose, of long trains, communication between nearby fixed points such as the signal tower, and the locomotive engineer or conductor, and communication between the yardmaster and the locomotives used in making up a train in large classification yards.

The radio equipment has been delivered to the New York Central railroad for installation on locomotives and fixed points and will be thoroughly tested under road and yard service conditions.

New Rail Motor Cars

The Rock Island Lines is the first railroad to substitute motorized power for both passenger and light freight service on branch lines.

The cars are of a new type which burn as fuel a petroleum distillate such as is used in residence oil furnaces. According to E. Wanamaker, electrical engineer of the Rock Island Railroad, the cars will solve the biggest problem now confronting the railroads of the middle west, that of economic and successful handling of traffic on branch lines.

The cars are capable of hauling a passenger train of 200 tons train weight at the speed of regular steam trains, and at a cost of less than half what steam trains cost today. Externally, the cars are like steel Pullman club-cars, with a power plant in the front. Each of the cars, which will seat 77 passengers, has a small baggage of express compartment, a smoking section, and a rear vestibule entrance such as any passenger coach has.

In addition to these five 72-foot cars for passenger service, two 40-foot all-steel cars have been converted with motor type of drive, but with dual equipment which will supply the additional power necessary for light freight duty. These were built at the Rock Island Horton shop.

In addition to their operating economies, the new cars afford a cleaner cab, are easier to operate, vibrate less than a steam locomotive, and require less attention.

Equipment Installed

The railroads of the United States in the first four months in 1927 installed 22,066 freight cars in service, according to reports filed by the carriers with the Car Service Division of the American Railway Association.

This was a decrease of 9,914 cars compared with the number placed in service during the corresponding period in 1926 while it also was a decrease of 35,860 cars compared with the number installed during the corresponding period in 1925. Of the total number placed in service in the first four months this year, the railroads installed in the month of April 3,056 coal cars; 2,156 box cars and 166 refrigerator cars.

The railroads on May 1 this year had 26,675 freight cars on order compared with 48,762 on the same date last year and 43,301 on the same date in 1925.

Locomotives placed in service in the first four months of 1927 totaled 634 of which 187 were installed in April. In the first four months last year, the railroads placed in service 759 locomotives and in the corresponding period in 1925, 601 were installed. Locomotives on order on May 1 this year numbered 217 compared with 654 on May 1 last year and 340 on the same date two years ago.

These figures as to freight cars and locomotives include new and leased equipment.

Railway and Locomotive Engineering

A Practical Journal of Motive Power,
Rolling Stock and Appliances

Published Monthly by
ANGUS SINCLAIR COMPANY
136 Liberty Street, New York
Chicago Office: 168 North Michigan Avenue
Telephone Rector 0746. Cable Address "Locong." N. Y.

Harry A. Kenney, Prest. and Man. Ed.
J. Snowden Bell, Associate Editor
W. E. Symons, Associate Editor
Thomas P. Kenney, Secretary

LONDON REPRESENTATIVE
The Locomotive Publishing Company, Ltd., 3 Amen Corner, Paternoster Row, London, E. C., England.

SUBSCRIPTION PRICE

$2.00 *per year,* $1.00 *for six months, postage paid in the United States, Canada and Mexico. For other parts of the world,* $2.50. *Single copies,* 20 *cents. Remit by Express Money Order, Draft, Post Office Order or Registered Letter.*

Mailing address can be changed as often as necessary—always give old and new address, and if you subscribe in a club, state the name of the agent.

Please give prompt notice when your paper fails to reach you regularly.

Entered as second-class matter January 15, 1902, at the post office at New York, New York, under the Act of March 3, 1879.

Where Are the "Ten and Twenty Per Centers"

We have become so accustomed to the presentation of the merits of a complete motive power unit, or of certain improved accessories that form an integral part of the locomotive with the absolute guarantee to show economy of ten to twenty per cent, that we almost automatically think of all such propositions as fixtures among the commonly called "ten and twenty per centers."

Sometimes, a bold aggressive salesman supported with the results of a most wonderful test of an attractive device, will, in presenting its money value or money making qualities, venture into or through the zone of economies representing twenty-five or thirty per cent. Such salesmen are quite rare and are considered bold and reckless by the regular "ten and twenty per centers."

We still hear the old story from some promoters, that if their device is purchased and used as directed for one year, it will pay for itself in savings or gross earnings in that period. However, all these propositions are so worded that the seller takes little or no risk and the buyer is left to work out his own salvation.

In the locomotive field in particular, guaranteed savings of ten, twenty and sometimes twenty-five per cent claimed for devices is so common that we hardly expect any other estimate of merit in the presentation of such propositions. This as a rule, does not apply to the specific part involved, which usually represents a very small portion of the cost of the entire unit. It therefore follows that while many claims of economies for some devices are not exaggerated, if properly analyzed, yet many of these propositions are on final analysis entirely different than what appears at first glance.

Elsewhere in this issue is described a small locomotive now in service in England that is claimed to show economies that are extraordinarily phenomenal. The cost of the engine was only about seven thousand dollars and the results of its performance indicate a saving of about eight thousand dollars at the end of one year's operation. This is based on a comparison of the new design of light locomotive and the conventional light steam engine formerly used.

The light steam locomotive has long been overdue for treatment such as our English cousins are according it in the interesting little engine referred to which possesses very novel features of design.

Railway Reclamation Work

Through the reclamation work now being conducted by the railroads of this country, some use is made of practically every bit of old material just as long as it is possible and economical to do so. As indicative of the extent to which this work is being conducted, old metallic roofing and empty powder or carbide cans are converted into tin buckets, cups and other tin ware while old broom handles and other mill refuse are made into staffs for signal flags such as are used extensively by the railroads. Scrap locomotive tire steel is being converted into hammers while even old hose is being used for the manufacture of baggage mats.

Canvas which has reached the end of its usefulness for the purposes for which it was originally bought is sent to the upholstering shops of the various railroads and there worked over into aprons for workmen, locomotive steam pipe covering and for other purposes. Broken leaves from springs are made by the reclamation departments into elliptic springs, while flues, which can no longer be used in locomotive boilers, are flattened and made into washers. Bolts are straightened and re-threaded, old timber cut into planks for crossings and other purposes, second-hand rail is made into guard rails, car wheels which have become flat again made available for use by grinding, while oily, dirty waste taken from journal boxes is cleaned and re-oiled and again used.

These are only a few instances of the hundreds of ways that have been found by the railroads to make use of old material which otherwise would be thrown into the scrap heap.

The reclamation departments of the various railroads now constitute one of the most important departments of the steam carriers for it is through the reclamation of old materials that substantial savings are being realized. Still greater efforts will be put forth along this line, according to plans discussed at the recent annual convention of the Purchases and Stores Division of the American Railway Association.

Transportation Prophecies

In this age of progress it is difficult to properly appraise engineering achievement and impossible to predict future development with any degree of accuracy. So much so, that as individuals we are liable to go wide of the mark in estimating the past or speaking prophetically of the future.

It is also usually true that the greater the man, the greater his errors or mistakes, when, as it sometimes happens, he may be on the wrong side of an important question.

Nowhere in the realm of engineering development or scientific research has there been greater strides made by civilized man than in transportation, notwithstanding numerous setbacks by those who either openly opposed progress or through misguided errors delayed its development.

The wonderful advancement in automobile and motor truck transportation in recent years has amazed those who at first spoke lightly of its probable development. This development has spoken more eloquent than pleasing to the ears of those interested in the financial aspect of steam railways, and they now have the all absorbing question of air transportation to reckon with. Some have felt so favorably impressed with not only the possibility, but to them, the probability of these forementioned agencies taking complete leadership in the transportation field, that there have been some rather gloomy pictures painted of the future of steam railways. We are inclined to the belief that in many instances well intentioned persons have become over enthused, if not slightly intoxicated mentally, as a result of some of the wonderful achievements of our automobile and air heroes, particularly the latter, and while too much credit or honor cannot be given those actually worthy, this does not necessarily spell annihilation or doom of steam railways by any means.

Recently, a prominent professional man returned to the United States from abroad and on arrival here gave out the following rather pessimistic views as to the future of our steam railways as follows:

"Twenty-five years hence, motors for land and air and electricity will be in full sway.

"Railroads and steam car lines will be placed in the same curious and amusing picture as depicted when one sees a horse-driven carriage in our streets.

"The steam railways will go the way of the stage coach and the horse lines have gone, and in this change New York City will have 15,000,000 people and the United States and Canada will take care of 35,000,000 motor cars instead of 23,000,000 as of today."

Thus spoke this traffic expert in sounding the death knell of steam and electric railways, as he forecast the doom of the horse 25 years ago.

This picture if taken at face value is not a very inviting one for those who are interested in our steam or electric railways, particularly the former. Bearing in mind, however, that those who "come to scoff," sometimes remain to pray, we beg to intrude the suggestion that instead of clothing ourselves in sack cloth and ashes preparatory to scrapping all our steam railways, which represent an investment, probably in excess of $23,000,000,000 and are the life blood of the nation, that we carefully review the situation by taking stock from all angles and thus try to find ourselves as it were in a less pessimistic atmosphere.

From the earliest records of civilized man, history is replete with precedents in just such matters as this, wherein over enthusiasm or stupidity have operated to the detriment of some great development.

One or two of the most striking examples might serve to emphasize the fallacy of the foregoing prophecy as to the sad ending of our splendid transportation facilities.

In 1835, when practical marine engineers proposed to propel ships wholly by steam power between England and America the leading English speaking engineer of that time not only condemned but scoffed at the idea and by way of ridiculous comment added that it was just as feasible to go to the moon as to go from Liverpool, England, to New York City in a steamship. The action of this celebrated engineer, who was the author of some 37 volumes of engineering work, actually delayed the development of marine engineering 15 to 20 years.

Let us come to a more recent epoch in transportation, that has a more direct application to the steam railways of this country, which if our expert is correctly quoted are due to go to the junk pile, post haste.

About forty years ago, following the first completed and successfully operated electric street railway in this country, there was such a wave of popular enthusiasm as to the future development of electricity as a prime mover that one could have been easily led to picture all other forms of motive power as being discarded at once. In fact, the press, including engineering or technical publications and prominent men in the engineering and commercial life of our country were about in accord as to its future.

In an authorized interview one of the leading railway executives of that time, and today a most distinguished citizen, predicted that in less than 25 years there would not be a steam locomotive in use on an American railway except possibly on some out of the way branch lines, or logging spurs.

What has actually happened in the interim not only to the railways but the prophecy of their destruction.

Tabulated Display of Certain Features of Steam Railway Development 1889 to 1925.

Year	Number Steam Locomotives	Tractive Power in Pounds	Miles of Line Operated	Number of Locomotives Built
1889	29,036	551,684,000	......	.....
1890	30,140	....	159,272	.....
1891	32,139	....	......	.....
1892	33,136	....	......	.....
1893	34,788	....	......	.....
1894	35,492	....	......	.....
1895	36,699	....	......	.....
1896	35,950	....	......	.....
1897	35,986	....	......	.....
1898	36,234	....	......	.....
1899	36,703	....	......	2,475
1900	37,663	....	......	3,153
1901	39,584	....	......	3,384
1902	41,225	839,073,779	201,673	4,070
1903	43,871	....	......	5,152
1904	46,743	....	......	3,441
1905	48,357	....	......	5,491
1906	51,672	....	......	6,952
1907	55,388	....	......	7,362
1908	56,867	....	......	2,342
1909	56,468	....	......	2,887
1910	58,240	....	......	4,755
1911	60,162	....	......	3,530
1912	61,010	....	......	4,915
1913	62,211	....	......	5,332
1914	63,510	....	......	2,235
1915	63,850	....	......	2,085
1916	65,021	....	......	4,035
1917	63,826	....	......	2,585
1918	64,410	....	......	3,668
1919	65,021	....	......	2,162
1920	66,511	....	......	2,022
1921	66,721	....	......	1,185
1922	66,280	....	......	1,303
1923	66,964	....	......	3,505
1924	67,441	....	......	1,810
1925	65,600	2,645,537,000	248,961	994
Percent Increase	125%	379%	56%	92,870

From the foregoing it is not only clear that the number of steam locomotives in actual service on our railways has not only increased by 125 per cent but in capacity about 379 per cent, and this does not tell the whole story as many locomotives have during this period been retired on account of age or functional depreciation.

It will be observed that from 1899 to 1925 there were built 92,870 new locomotives; add to this the 36,703 reported in service in 1899, and it is evident that 63,973 locomotives or about 3,460 per year have been retired from service. During this period only about 379 to 400 electric locomotives were placed in service on steam railways.

The predictions of 1887 relegating the steam locomotive to oblivion in 25 years were not well founded.

There have been great forward strides in transportation since then and there will be greater strides in future is a safe estimate to make, depending however, entirely on the engineering and inventive genius of the leaders in their respective fields of activity and the necessity and practicability of conversion.

But, any suggestion that the billions now safely invested in our splendid steam railways is in danger of being thrown into the scrap heap, is not entitled to the dignity of consideration.

It appears quite pertinent to this subject to also point out another angle which was strongly urged on our railway managers and owners through a greater part of the period in which the inferiority of the steam locomotive as a prime mover was so openly advanced, particularly by electricians who were more or less interested in selling electric equipment, but many of whom were lacking in knowledge of railway construction or operation.

According to them, wonderful returns would immediately result from the electrification of any considerable portion of a railway system or, better still, the complete electrification of all steam railways.

Electrification was held out as a sure cure for any and all railway troubles, especially those that might even have symptoms of financial ills, and as an absolute *sure cure* for all thus afflicted.

There are just two steam railway systems of any importance in this country that changed any considerable portions of their lines from steam to electric power. Each of these lines shortly prior to the conversion were considered top notchers in the way of high standards, their securities being in great demand at the high prices.

Shortly following their conversion there was not only an absence of the increased prosperity so loudly proclaimed as sure to follow, but quite the reverse. Each suffered serious financial reverses, first lowered and then passed their dividends. One had to seek protection of the federal courts and is still in the hands of receivers, while other lines in the same or adjoining territory that stuck to and developed the steam locomotive, not only weathered the storms of adversity of that period, but most of them continued their dividends regularly. This particular phase of the railway situation was reviewed at length in RAILWAY & LOCOMOTIVE ENGINEERING of March, 1925, pages 76-77 and also in July, 1925, pages 211-212.

The 4-4-0 Type Locomotive in England

By ARTHUR CURRAN

In the October, 1926, issue of RAILWAY AND LOCOMOTIVE ENGINEERING there was some mention of the 4-4-0 type as used both in America and in England. At that time, stress was laid upon the duties which this type might be expected to perform under the conditions now prevailing. There is, however, much of a purely historical nature which might repay whatever attention that is bestowed upon it. For purposes of comparison, such a study is presented herewith.

To those who are familiar with the modern motive power of the Great Western Railway of England—either by personal observation or by means of photographs—it may come as something of a surprise that the groups of engines in service just prior to the modern era were of a design far different in many important respects. It will be a matter for still further wonder that some of these old engines actually were hauling important trains only a short time ago, and that a few may be still so engaged.

One of the most interesting cases of this kind that has come to my attention is that involving the "City of Hereford" on an up Worcester express, and shown in an accompanying photograph. The "City" class consists of twenty engines, and made its appearance about twenty-five years ago, though the ideas which it exemplifies had their origin on the G. W. R. long before that. The use of outside frames—both main and engine-truck—had been familiar enough on the road for many years, and the practice of employing inside cylinders was common enough all over Great Britain. It was the use of an extended smoke-box, supported on a saddle, which first drew attention to a group of engines, one of which was named "Atbara," and from which the "City" class derived many of its characteristics. That must have been about 1900, at which time one commentator referred to the practice as "suggestive of American rather than English design." If this commentator had known how much more 'American" subsequent classes were to be, it is hard to know what he would have said! The dimensions of the "City" class follow:

Cylinders 18 x 26 inches, drivers 80 inches, boiler 58¾ inches at front end and 66 inches at throat, working pressure 200 lbs., tractive effort 17,790 lbs.

An engine of this class—"City of Truro"—acquired great renown by reason of its part in the record run of May, 1904, which "hung up" figures of 65.49 m. p. h. including stops and 66.39 m. p. h. excluding stops between Plymouth and London, via Bristol. The maximum speed attained on this run was 102.3 m. p. h. The train consisted of five postal cars between Plymouth and Bristol, and was handled on this part of the run by "City of Truro." Between Bristol and London the train consisted of four postal cars and was handled by "Duke of Connaught" which, if I am not mistaken, was of the 4-2-2 type.

4-4-0 Type Locomotive Hauling Train on Great Western Railway, England

Mention of the 4-2-2 type brings to mind several points which may properly receive attention at this time. The G. W. R. was originally a broad-gauge line, a fact which accounts for the general roominess of the right of way. The work of changing the system to standard-gauge was completed about thirty-five years ago, at which time the standard express engines on the road were of the 4-2-2 type, and handled, among other trains, the famous "Flying Dutchman," which consisted of "bogie stock," throughout, and was much in advance of the passenger equipment then commonly used in Great Britain.

At various times, the statement has been made that a train of the same name was operated in broad-gauge days. Without questioning this statement, it may be remarked that such a train could not have equalled, either in appointments or speed, the much better known 'standard-gauge train.

This standard-gauge "Dutchman" used to leave London at 11:45 A. M. and reach Exeter at 4:09 P. M. By the route then followed, the distance was 194 miles; from which it will be seen that the pace was fairly swift.

As before mentioned, the engine was of the 4-2-2 type, having cylinders 19 x 24 inches, 92 inch drivers and weight of 109,760 lbs. without tender. The boiler was straight and 51 inches in diameter, carrying 160 lbs. of steam per square inch, and having a centrally located dome with a brass casing. The smoke-box was short, and the fire-box was slightly raised, and had the safety valve mounted upon it. Outside frames were used, but the entire engine was so neatly designed that there was no suggestion of undue bulkiness. Inside cylinders were used, as a matter of course.

The "Dutchman" normally consisted of six cars, though more could have been handled by the engine. (And probably were, at times). The picturesque name of the train, the gay little engine and the excellent time made in those days contributed to the enjoyment of all concerned. As the old saying goes: "A pleasant time was had by all."

4-4-0 Type Locomotive on the London, Brighton & South Coast Ry.

Today, not one of a class of engines, which must have numbered about sixty, remains. But the "Dutchman" was the forerunner of the superlatively fast and punctual trains of the present time; and, as such, is worthy of what recognition we can give it.

The use of the 4-4-0 type on the G. W. R. was due very largely to the existence of heavy grades in the "West Country," where a driving-wheel diameter of 68 inches was necessary in order to get sufficient power. Ultimately, however, the 4-4-0 engines with inside cylinders and outside frames were classified into four groups; the "Duke" and "Bulldog" classes with 68 inch drivers, and the "Flower" and "City" classes with 80 inch drivers.

It is of interest to note here that the "Athara" class was later fitted with the coned type of boiler and incorporated into the "Flower" class.

Before leaving the subject of these unusual locomotives, it is proper to add that, in July, 1903, the "City of Bath" hauled a Royal Special from London to Plymouth, via Bath, 246⅝ miles in 233½ minutes. This was a non-stop run.

As an example of conventional British design, the 4-4-0 of the London, Brighton & South Coast Railway affords an interesting comparison. Engines of the general style illustrated by the accompanying photograph hauled the "Pullman Limited" and other well-known trains at the time dealt with in this article. Dimensions: Cylinders 19 x 26 inches, drivers 81 inches; weight, without tender, 115,000 lbs.; boiler pressure 180 lbs. per square inch. This class was designed to haul trains weighing 300 tons at 50 m. p. h., and, as shown in the photograph, is fitted with extension front and saddle, both of which features were applied after engine had been in service for some time.

In the foregoing notes, no attempt has been made at anything more than the presentation of a few facts concerning the production of the commodity known as transportation in the Old Country.

Centenary of the Baltimore and Ohio

A world's fair in transportation, or what is believed will be the largest and most complete out-door historic railroad pageant ever displayed, will be the chief attraction of the Baltimore and Ohio's two-week celebration at Baltimore, Maryland, September 24th to October 8th. This will be the principal function of the year in connection with the Baltimore and Ohio Centenary.

President Coolidge is expected to be present on opening day. Everybody is invited. There will be no admission charge.

The centenary grounds will be located on the company's property in the southwestern outskirts of the city at a point called Halethorpe, close by the railroad and the Baltimore-Washington highway. Work is progressing on the 1,000 acres which will be the site of the exposition. Plans include a loop track over a mile long, nearly two miles of other track and a grandstand seating 12,024 persons. Within the 25-acre loop space, various replicas of buildings and railroad structures will be erected, representing century-old associations, among which will be one of Mount Clare Station, the oldest in the world.

The Hall of Transportation will house many exhibits showing the development of rails and ties, not only from the Baltimore and Ohio's earliest used, but going back to those on the tramways of England in the 18th and 19th centuries. The development of many railroad appliances, notably the air brake and the signal also will be displayed, in careful detail. There will also be shown reproductions and models of the earliest European locomotives, equipment and conveyances, even to the vehicle in use of the days of the Pharoahs.

There will be special platforms for those arriving and departing by train or automobile contiguous to a subway passing under the railroad so that no one will have to cross the tracks either going to or coming from the exposition grounds.

In the transportation expositions of the 1876 Centennial, the World's Fair at Chicago in 1893 and the St. Louis Fair of 1903, the Baltimore and Ohio took a prominent part, but these were held indoors and all the various historical types of locomotives were not in motion. By the use of the loop-track for the passage of the pageant in the open, at a season of the year when the weather is generally favorable for outdoor affairs at Baltimore, an opportunity is afforded to display a mobile and articulate panorama three miles long as the many units of the pageant will move under their own power.

Use of Fuel Oil Under Locomotive Boilers

The development of the oil-burning locomotive is characterized as a strictly American achievement in a review on the subject by the United States Department of Commerce. Experimentation in the burning of oil under locomotive boilers began soon after the initial discovery of petroleum in Pennsylvania in 1859. In those days, however, the high price of fuel oil, as compared to that of coal, retarded the general adoption of oil in that field of service.

It is significant to note that the first road to carry on extensive experiments along this line was one in California. At that time, 1879, no oil fields had been exploited in the western part of the country; and the oil used had to be transported by water from the Atlantic coast. Since 1906, the Southern Pacific Railroad has burned oil exclusively under its locomotive boilers.

Mechanical Division Meeting of the A. R. A.

Reports and Papers of Four Day Session Reflect Improved Transportation Efficiency

The eighth annual meeting of the Mechanical Division of the American Railway Association was held at Montreal, Quebec. L. K. Sillcox, chairman of the division and general superintendent of the Chicago, Milwaukee & St. Paul Railway presided at the sessions. Something over six hundred attended the meeting. The speakers at the opening session were the Right Honorable George P. Graham, P. C., former Minister of Railways and Canals for the Dominion of Canada, and R. H. Aishton, President, American Railway Association.

Other speakers during the convention included Samuel O. Dunn, of Chicago, Editor, *Railway Age;* Interstate Commerce Commissioner Frank M. McManamy; Professor A. T. Wood, Pennsylvania State College; G. E. Smart, Chief of Car Equipment of the Canadian National Railways; A. A. Potter, Dean of Engineering, Purdue University, Lafayette, Indiana; W. T. Jackman, Professor of Political Economy, University of Toronto, and William J. Cunningham, Professor of Transportation, Harvard University. M. J. Gormley, chairman of the Car Service Division of the American Railway Association and A. G. Pack, Chief Inspector, Bureau of Locomotive Inspection of the Interstate Commerce Commission.

Abstracts from some of the reports and papers are presented in this and the following pages, and others will be published in subsequent issues of this magazine.

More Intensive Use of Equipment

Address by Chairman L. K. Sillcox

We are today attending conventions to obtain new ideas for self improvement and we are endeavoring to learn how to do better work in the future than in the past. The man who misses that point in a convention is disregarding the very reason for his attendance. We need to give due credit to the value of service rendered the railway industry by manufacturers of equipment and specialties and of the part they have contributed towards its upbuilding. In meeting conditions as they exist, at this time, we have much to do in the way of co-ordinating the use and adoption of new tools and devices with existing practices and plants in order to gain the greatest practical benefit for effective operation. Every precedent of the industry is subject to question in the light of changed conditions and the fact that we have always done something in a given way is a good reason for questioning that practice with a view towards improvement.

From the operating ratios and trends for Class I carriers in the United States it is apparent that the transportation expense ratio was 34.25 in 1926 and 32.60 in 1916, the difference still being 1.65. In the same way maintenance of equipment ratio was still 3.43 greater, maintenance of way 1.85 and all other expenses 0.65 greater than in 1916. The difference of 3.43 for maintenance of equipment is somewhat due to the difference of 0.3 in depreciation and retirement charges and these will not decrease for some years to come because of the price range of equipment acquired since 1916.

In the cost of maintaining equipment this may be divided roughly into (1) repairs, (2) depreciation and retirements, (3) miscellaneous such as superintendence, injuries to persons, stationery and printing, joint facilities, etc., and (4) repairs to facilities used for maintaining equipment.

Repairs to rolling stock increased to a larger extent than charges for depreciation and retirements with a constantly increasing ratio for repairs to maintenance facilities due to lack of turnover and greater demand being made upon obsolete tools and power generating facilities than ever before. Locomotive and freight car repairs are shown separately on this chart to indicate to what extent they affected the total and this indicates that the proportion expended for freight car repairs has decreased more rapidly since 1921 than locomotive repairs due to a larger percentage of new units added in the case of freight cars as compared with locomotives. Passenger car repairs increased 33.8 per cent in ratio, the difference being that the ratio was 1.024 in 1916 and 1.370 in 1925.

In the case of freight locomotives the following shows the gross ton miles hauled and the relation of the locomotive ton-mile to gross ton-miles hauled.

	Billion Gross Ton-miles Hauled	Billion Net Ton-miles Hauled	Billion Loco. Ton-miles Run	Per Cent Loco. Ton-Miles: To Gross Ton-miles Hauled	Per Cent Loco. Ton-Miles: To Net Ton-miles Hauled
1921	869	761	108	12.4	14.2
1922	928	815	113	12.1	13.8
1923	1,124	987	137	12.1	14.0
1924	1,086	954	132	12.1	13.8
1925	1,162	1,023	139	11.9	13.5
1926	1,246	1,099	147	11.8	13.3

This shows that more work has been done by individual freight locomotives and that the gross ton-miles hauled per locomotive ton-mile, arrived at by deducting the net ton-miles from the gross ton-miles including locomotive and tender to indicate the locomotive ton-mile, resulted in a lesser per cent of the total in 1926 than in 1921, or a reduction from 12.4 per cent to 11.8 per cent, a benefit of 5 per cent resulting. The gross ton-miles in 1926 were 43 per cent to 13.3 per cent, a benefit of 6.3 per cent resulting. The gross ton-miles in 1926 were 43 per cent more than in 1921. The net ton-miles were 44 per cent more. It is thus apparent that the relation of net ton-miles carried to total train weight has improved. The locomotive ton-miles in this period increased only 36 per cent as compared with 43 per cent for total gross ton-miles, this being another way of expressing the greater efficiency obtained. The average miles run per locomotive per year decreased in the face of this improvement in performance, indicating the need for close study and positive methods to be applied in assiting still greater utilization of the transportation plant. The aggregate tractive force capacity of all classes of locomotives, that is freight, passenger and switch, increased 10 per cent in the same period, which is less than the business increase.

It is interesting to note, in this connection, the cost per locomotive mile for repairs, fuel and enginehouse expense from 1916 to 1925, inclusive, as shown in the following tabulation.

Cost Per Locomotive Transportation Service Mile

	Repairs, Cents	Fuel, Cents	Enginehouse Expense, Cents
1916	11.43	11.56	3.02
1917	14.10	22.43	3.85
1918	25.74	29.46	6.94
1919	29.35	30.05	8.37
1920	35.01	39.69	10.03
1921	30.70	35.53	8.96
1922	29.25	34.11	8.21
1923	33.12	31.18	7.66
1924	28.89	27.00	7.30
1925	27.88	24.72	6.90
Per cent in 1925 over 1916	128	69	144

In this respect the cost per mile for fuel was 69 per cent greater in 1925 than in 1916, whereas the cost of the enginehouse handling was 144 per cent greater, from which it is evident that improvement in roundhouse facilities and methods is an important issue for consideration. At the same time in this respect locomotive repairs were 128 per cent greater.

Enginehouse expense has not decreased in cost as rapidly as it should, particularly in view of the fact that the increased utilization of power should reduce the frequency of enginehouse care in relation to mileage run. Terminal facilities are of the greatest importance in this respect. Improvements along this line may be considered from two viewpoints, one being the design and equipment of the enginehouse plant and the other being the number of roundhouses needed for a given service. In the latter case, it has been found that the average distance between roundhouses ranges from 60 miles on some lines to more than 100 miles on other lines and it is, at once, apparent that the cost of enginehouse expense, in relation to mileage run, will be high or low according to this general situation. In the other case, it is of great importance that track layouts be such as to reduce hostler service to a minimum since this is a rather large proportion of enginehouse expense. This applies to inbound and outbound tracks, ashpit location, coaling, watering and sanding facilities, turntable capacity, etc. Aside from these elements, the handling of cinders is also a large expense and devices for reducing the labor cost are desirable. The cost of boiler washing is a particularly large element in this expense and water pressure, together with hot water facilities determines the efficiency of this work, affects the cost and also affects the fuel performance in a measure. Hot water washout plants result in making roundhouse stalls available to a greater extent through speeding up the operations and also save locomotive fuel used in firing up. The installation of such facilities has added to the improvement in fuel performance in recent years. The indications are that engine house expense will eventually cost approximately 6 cents per mile or less until there is an increase in the number of new or rehabilitated pivotal terminal facilities provided for more efficiently handling locomotives when a further reduction in cost per mile may be expected.

Progress has been made in the design, maintenance cost and performance of freight train cars in the ten year period referred to. Car shortage has practically disappeared. At the same time the number of freight cars owned by Class I carriers increased only 4.7 per cent but the aggregate carrying capacity increased 16.3 per cent while the average carrying capacity increased from 41.0 tons to 44.8 tons, or 9.2 per cent. The proportion of the total cars which are of steel construction, that is, all steel, steel framed or steel underframe, etc., increased from 57 per cent to 73 per cent.

The cost of maintenance increased from $83 per car to $156, or 88 per cent. The cost of maintenance per car mile increased from 81 cents to 1.39 or 71 per cent, and during this time the average miles run per car increased from 10,000 to 11,150 or 9 per cent. It has been shown that the maintenance cost of freight cars declined more rapidly than that of locomotives in the past five years, and the conditions bringing this about differ considerably in the matter of policy. The life of a freight car is about two-thirds that of a locomotive; this at least has been the past experience. For that reason the renewal periods occur more frequently and obsolescence is a greater factor. The rate of turnover of freight cars has been found to be high on some railroads and where this has been consistent with what has been needed the maintenance cost has been reduced very materially. The following tabulation shows the per cent of total cars retired and acquired in each year for the past ten years and other elements which affected maintenance and performance:

	Average Rate of Turnover Per Cent	Per Cent Cars of Steel	Average Carrying Capacity in Tons	Repair Cost Per Car Year, Dollars	Repair Cost in Cents Per Car Mile	Repair Cost Per Aggr. Ton Capacity, Dollars	Ratio of Repairs to Oper. Rev., Per Cent
1916	5.1	57	41.0	83	81	2.06	5.288
1917	3.8	61	41.5	97	93	2.28	5.414
1918	2.9	61	41.6	164	1.70	4.00	7.927
1919	2.9	62	41.9	186	2.08	4.50	8.700
1920	2.3	65	42.4	252	2.54	6.04	9.574
1921	2.8	66	42.5	199	2.29	4.71	8.457
1922	4.9	67	43.1	176	1.90	4.12	7.300
1923	9.2	71	43.8	204	1.85	4.70	7.560
1924	5.8	73	44.3	160	1.52	3.66	6.433
1925	5.3	73	44.8	156	1.39	3.52	6.097
Per cent over 1916		29	9.2	88	71	70	15

These trends indicate that the turnover has affected the cost of repairs in that the cars of wooden construction have been retired very largely since 1922. The characteristics of turnover trends will change somewhat as the proportion of cars of steel construction become larger, as this may increase the average life, provided current repairs are adequately maintained.

The effect of car construction and maintenance on train performance is shown in the following tabulation as to gross tons per train, excluding locomotive and tender, net tons per train and the resultant weight of cars per train:

	Gross Tons Per Train	Net Tons Per Train	Car Wt. Per Train	Per Cent Net	Per Cent Car Wt.	Frt. Ton-miles Per Loaded Car Mile
1921	1,435	651	784	45.3	54.7	34.2
1922	1,466	676	790	46.1	53.9	39.7
1923	1,539	713	826	46.3	53.7	40.3
1924	1,588	715	873	45.0	55.0	44.3
1925	1,620	744	876	45.9	54.1	44.4
1926	1,737	772	965	44.4	55.6	....
Increase	21 per cent	18 per cent	23 per cent			

This shows that the per cent of car weight to total train load has been increasing and the per cent of net load carried has been decreasing and that the question of car construction in relation to dead weight is before us to a marked degree. It is necessary to await the results of the future to determine whether the question of car weight and design is going to result in a cheaper transportation cost from this viewpoint. We are, nevertheless, faced with the fact that in this period gross tons per train increased 21 per cent, while net tons per train increased only 18 per cent, and at the same time car weight increased 23 per cent. Much has been said about obtaining greater loading per car would increase in proportion and thus compensate for the work which it has been necessary to do to operate larger trains with greater reliability of movement. The strengthening of cars has been a contributing factor in the reduction of transportation expense, even though the average load may not have increased the earnings per car as desired. The load factor has not increased with the load carrying capacity, but the net ton-miles per freight car mile increased approximately 30 per cent in the latter portion of this period.

In the matter of freight car maintenance much can be done in classifying freight equipment by age, character of construction, frequency of heavy repair work, etc., so as to bring about heavy repairs in a balanced manner. A study of the relation of light repairs to heavy repairs develops the fact that with a given ownership the character of construction will lend itself to a rather definite period of reconditioning. Progress along this line can be made to a considerable extent, but it involves the regulation of shop forces as between light and heavy work to permit of establishing more definite plans for providing facilities of proper capacity. While this has been worked out in a general way, much can be done to concentrate heavy freight car repairs and reduce the cost by reason of volume handled somewhat similar to the back shop arrangement for locomotives. Any attempt to do heavy repair work at light repair points will naturally increase the cost of such work.

The number of passenger train cars owned by Class I carriers increased only 4.8 per cent in the past ten years. The character of ownership as to types of cars shows that the number of coaches increased only 0.4 per cent, dining cars increased 8 per cent, baggage cars increased 29 per cent and miscellaneous types increased 14 per cent in this period, but combination cars remained practically the same, and there was a decrease in the number of railroad owned emigrant, parlor, sleeper and postal cars. The number of cars of steel construction was 32 per cent of the total in 1916 and this increased to 51 per cent in 1925.

With the increase in the number of steel constructed cars, there has been practically no appreciable decrease in maintenance cost, and we are, therefore, confronted with the problem of further improving the character of materials used so to reduce the heavy repair frequency. The major portion of repairs to passenger cars is heavy repairs, and in this respect passenger car maintenance differs in character from that of locomotives and freight cars. That being the case, the question of passenger car designs and material is very important and should be given careful study.

Very little, if any, improvement has been made in the character of repair facilities to handle passenger car work. It would seem well worth while to have this matter studied for the general good, and each carrier can well afford to go into this question very fully. The efforts along this line will be well worth while and should be made so as to bring the relative cost of maintenance of passenger cars to a more satisfactory basis. In certain sections due to competitive conditions, the proper upkeep of passenger train cars is almost a first call upon management, because where passenger service is not maintained upon a high level, in such circumstances, the railroad may fail largely in attracting an adequate proportion of freight business and no members of the railroad family have to bear this urge more peculiarly than do the mechanical officers, thus adding to their expenses for the good of the railroads as a whole, being in substance a form of public contact.

The year 1916 was taken merely as a matter of a ten year comparison and that year in itself was no particular criterion. However, we are interested in the actual cost of repairs and the relation of the cost of maintenance and operation to operating revenue. When using the latter as the basis, it has been found that locomotive repairs consumed 36.8 per cent more of every dollar earned in 1925 than in 1916, pasenger car repairs consumed 33.7 per cent, freight car repairs 15.3 per cent, enginehouse expense 28.1 per cent and transportation expense 7.1 per cent, with a decrease of 4.7 per cent in the cost of fuel.

Locomotive repair costs can be reduced by owning and maintaining only a sufficient number for the business handled and have large locomotives and maximum utilization in freight service consistent with a balance between transportation expense as to trainmen, repairs, enginehouse expense and fuel consumption; and having maximum utilization of passenger power with as small a number of units as is consistent with the business and of a size not too large for the trains handled.

Passenger train car repairs costs can be reduced by improving materials and design with a view to obtaining greater service between heavy repairs and at the same time increasing the mileage performance by better utilization so as to keep to a minimum the number needed for the service.

Freight train car repair costs can be reduced by more systematic attention, maximum utilization and proper construction. Questions of design are being given careful consideration by this association and work along this line has shown marked results. Repair costs are affected by the number of cars maintained and it is imperative that the number of reduced to actual requirements. It is possible to obtain greater utilization of freight cars because the mileage run per cent per year is still too low. Giving cars major repairs at proper intervals to avoid running them beyond the major repair period systematizing heavy repair work and reducing the amount of damage to cars in trains and yards as well as by shippers should result in reducing the cost.

Enginehouse expense can be reduced by operating only those terminals which are actually needed, accomplished by increasing the length of runs and by improving terminal facilities actually required.

Doubtless, further savings in fuel cost will be made in the future by increasing the locomotive performance and decreasing the turnings in relation to the mileage run.

Transportation expense has a considerable bearing upon maintenance expense as the two are more or less related. The utilization of power and cars can be increased, and while this may mean larger and fewer trains, the question of balancing the savings from such operation with what may be incurred in train and engine crew overtime as compared with running lighter and more trains to reduce transportation cost accordingly in relation to equipment performance.

Much remains to be done by this and other railroad associations in the matter of improving operating and maintenance conditions. The unit rate of revenues and the revenue volume do not fluctuate uniformly with the unit rate of expense and consequent expense volume, but the work of improving the performance and reducing the cost will constantly remain before us and efforts along such lines are laudable.

Report on Safety Appliances

By H. A. Johnson, Director of Research in Charge of Power Brake Investigation

The investigation of power brakes and appliances for operating power brake systems has been carried forward during the year and the director of research is able to report substantial progress. The 1926 report covered the reasons for the investigation; the agreement to a general plan of procedure by the committee on Safety Appliances of the Mechanical Division of the A. R. A. and the Bureau of Safety of the I. C. C.; the appointment of a director of research; the reconstruction of the A. R. A. test rack at Purdue University, including the development and building of new test instruments; the placing of orders with the Automatic Straight Air Brake Company and the Westinghouse Air Brake Company for 150 sets of freight train air brake equipment which will meet the tentative specifications and the I. C. C. requirements; the preparing of a schedule of tests which was agreed to by the interested parties; the building up of an organization of trained men to carry on the work.

The test rack was first equipped with new standard Westinghouse type K triple valves. The tests on these valves started on November 30, 1925, and were completed on June 30, 1926. During this time more than 600 tests were run and it was necessary to stop the tests three times for cleaning and lubrication of the triple valves. Upon the completion of the tests, the type K equipments were entirely removed from the test rack and the Automatic Straight Air Brake Company's equipments installed. These equipments had been received at Purdue University about April 1, 1926. The equipments purchased from the Westinghouse Air Brake Company were received July 1, 1926.

After the installation of the A. S. A. equipments was completed, the test rack was turned over to the representatives of this company and they made such preliminary tests as they deemed necessary to satisfy themselves that their equipments were in proper condition and were ready for the official tests. The tests on this equipment started on August 17, 1926, and are still in progress. This equipment has been submitted to more than 600 tests, including single triple valve tests, 100-car train tests representing level road conditions, 100-car train tests representing grade conditions. Since starting the tests on the A. S. A. equipments, it has been necessary to stop three times to clean and lubricate or make adjustments of the mechanism.

The Automatic Straight Air Brake Company claims that their equipment is superior to the Westinghouse type K equipment and possesses the following new functions:

1—That only a service application of the train brakes will occur when a service reduction of brake pipe pressure is made.

2—The ability to obtain effective emergency brake cylinder pressures after a full service application or after release following a full service application of the brakes.

3—The ability to maintain brake cylinder pressure against ordinary leakage.

4—The ability of the engineman to control the release of pressure from brake cylinders and effect such release by graduated steps in order that he may decrease as well as increase brake cylinder pressures as required to control at relatively uniform rates the speed of trains.

The series of tests with all cars in the train equipped with the Automatic Straight Air Brake Company's equipments will be completed during the first of April, 1927.

Following this the A. S. A. equipments will be removed from 50 of the 100 cars and the Westinghouse standard K equipments replaced on these 50 cars of the 100-car train will be equipped with A. S. A. equipment and the remaining 50 cars of the 100-car train will be equipped with Westinghouse type K equipment In the first half of the train, the two kinds of equipment will be alternated every five cars and in the last half of the train they will be alternated every 25 cars. When the test rack has been set up in this manner, a series of tests will be made for the purpose of showing the effect of each type of equipment upon the other, or, in other words, to determine if the Automatic Straight Air Brake Company's equipments will operate harmoniously with the type K equipments in the same train. It is obvious that a new air brake equipment could not be adopted for freight cars in interchange unless it was designed so that it would function satisfactorily when operated in the same train with the standard air brake equipment.

The Westinghouse Air Brake Company has submitted for trial two new air brake equipments; one of which, it is claimed, complies with the tentative requirements and specifications of the Interstate Commerce Commission as stated in its preliminary report and conclusions dated July 18, 1924, and the other equipment contains the ideas of the Westinghouse Company on the desirable functions of an air brake equipment for long freight trains. After the completion of the tests on the A. S. A. equipment, the two new Westinghouse equipments, including the test to determine whether these equipments will operate harmoniously with the present standard type K equipments.

Two inspection days have been held during the conduct of this investigation when all the members of the Mechanical Division of the A. R. A. were requested to send representatives to witness the performance of the brake equipments upon the rack and to become acquainted with the method of carrying on this investigation. The first inspection day was May 12, 1926, when the standard type K equipments were on the test rack. The second inspection day was November 12, 1926, when 150 men representing 65 different railroads and 10 other companies and associations observed the operation of the A. S. A. equipments on rack representing a 100-car train.

During the year the research organization has been considerably increased. The results are being calculated and tabulated as the test proceeds. One part of the organization works up the results. The tabulation and analyzation of the vast amount of information from the trainagraph records has proved to be a large task. The organization now comprises 70 men; approximately three fourths are engaged in working up the records and one fourth engaged in carrying on the test work in the laboratory.

Purdue University is doing a large amount of engineering and agricultural extension work which bring many meetings of associations and many visitors to the University. These visitors are from all walks of life, representing farmers' organizations, industrial organizations, bankers and business men. All these delegations visit the air brake research laboratory and are greatly impressed with the work being carried on by the Association in the interest of greater safety and reliability of train operation. This publicity is very far reaching in the building up of good will toward the railroads. The Bureau of Safety of the Interstate Commerce Commission has maintained from one to three representatives at Purdue University since the air brake tests started and these representatives make daily reports to the Director of the Bureau of Safety, keeping him in constant touch with the progress and the results being obtained. Similarly, the Automatic Straight Air Brake Company and the Westinghouse Air Brake Company have their representatives present at all times and they also make daily reports to their companies on the work accomplished.

An invitation is again extended to all railroad men to visit the power brake laboratory at any time.

Report on Automotive Rolling Stock

In order to secure information on the present use of automotive rail cars on Class I railroads, a general inquiry has been made regarding the size, power and age of each such equipment. In addition, statements have been secured from some twenty railroads known to be large users of rail cars, giving detail information as to costs of operation for the calendar year 1926, reliability of service and general operating experience.

Number of Cars.—The number of cars listed in the replies total 332, of which 189 are mechanical drive and 133 electric drive. This type of equipment was originated in 1905, and had a steady growth until 1915, after which there was a period of inactivity until 1921, when renewed interest was shown, and from that time onward there was a rapid increase in the number of cars, the number being trebled from 1921 to 1926.

Transmission.—The number of mechanical drive cars was approximately double that of the electric drive cars until 1925, during which year the number of mechanical drive cars did not increase at the prevailing rate, and it appears probable that by the end of 1927 the number of electric drive cars will equal or exceed that of the mechanical drive cars. Some of the reasons for this are to be found in the greater reliability and serviceability of the electric models, simplicity of control and of double end operation.

There are also a few storage battery cars which were included under the electric drive cars. There is a general tendency at the present time to convert the storage battery cars to gasoline electric drive. There is one experimental hydraulic transmission in use on the New Haven, but the cost figures on the gear are not indicative of normal operating conditions because of accident repairs not chargeable to the hydraulic feature. The fuel costs on this car are comparable to those obtained with electric drivers, but there is an additional cost for transmission oil which has been high due to occasional leakages.

The power of electric drive cars was between 175-200-hp. until the year 1925 when a number of 250-hp. engines were introduced and several railroads put into operation double power plant cars running between 400-500-hp., raising the general average to 273-hp. for this last year. The average horsepower of mechanical cars started out in 200-hp. for this last year. The average horsepower of mechanical cars started out at 200-hp. with the McKeen units and has varied somewhat erratically due to the fact that in 1912 a group of 60-hp. cars was built, in 1917 a 300-hp. car was put out, and again in 1921-22 small engines were temporarily vogue. At present time there seems to be a tendency to limit the mechanical transmission to cars in the neighborhood of 150-hp. or less. Cars of 180-275-hp. are used with single trailers, and cars over 400-hp. are used with from two or three trailers.

The average light weight per horsepower for a single mechanical car is about 350 lb. and when these cars are operated with trailers the weight per horsepower rises to approximately 630 lb. Electric drive cars average approximately 400 lb. per horsepower operated without trailer, or 700 lb. per horsepower with trailers. The weight per foot of car length is approximately 750 lb. for small mechanical cars, and 1,100 lb. for large mechanical cars. Electric drive cars average 1,400 lb. per foot of car length, due in part to the increased weight of the transmission and in part to the fact that these cars have in general heavier duty engines and are of more substantial construction throughout.

Power Plant—Nearly all rail car use six-cylinder engines, the four-cylinder engine being now confined to the smaller type of car, having only 60-7-hp., the one notable exception to this being the four-cylinder and eight-cylinder Diesel Diesel engines on the Canadian National, which are rated at 200 hp. and 400 hp.

Table 1—General Average of Rail Car Operating Costs as Reported by Several Class I Railroads

Cents Per Mile

Type of Equipment	Mechanical Single	Mechanical Trailer	Electric Single	Electric Trailer
Crew	18.69	22.93	18.85	20.79
Fuel	4.59	6.05	10.45	12.10
Lubricating oil	.86	.90	.88	1.00
Supplies Cleaning Enginehouse	2.83	3.12	1.66	2.10
Repairs	11.40	10.85	6.31	5.45
Total	38.37	43.85	38.15	41.44
Average daily mileage	101	122	165	203

The limiting cylinder size of modern cars is 7½ in. by 9 in. for gasoline engines, although some of the older gasoline and distilled engines had 8 in. by 10 in. by 12 in. cylinders. Diesel cylinders now in use measure 8¼ in. by 12 in. It is not thought likely that the gasoline cylinder will come back to these very large sizes, but there is not reason to believe that the Diesel engine cannot be used with cylinders as large as may be desired.

Engine speed of the gasoline engines of 20 years ago was limited to 350 r.p.m., which was increased until 1925 there were a number of cars operating at 1,600 r.p.m. and 1,700 r.p.m., but the best practice at the present time seems that this is increasing to a rated speed of 900 r.p.m.

Cooling System—The preponderance of cooling systems are built around cellular radiators mounted either on the front or the side of the car. In some cases the front-mounted radiators are assisted by small overhead radiators which are normally dry, but come into action when the engine speed is increased beyond the idling speed.

A few cars have been built, notably nine on the Canadian National and two on the N. Y., N. H. & H., in which the radiation is of the finned-tube type mounted on the roof of the car and dependent for air circulation solely on the motion of the car. This has two chief advantages; the first being that the radiation system may be only partially filled when the car is standing, so that the water is confined entirely inside of the car body, thus minimizing the danger of freezing in cold weather; secondly, the flow of water may be by-passed at engine-idling speeds so that excessive cooling will not be experienced when coasting down long grades with the throttle closed. It also makes for rapid warming up of a cold engine.

Air circulation through the cellular type radiators is obtained by mechanicaly driven fans on mechanical cars, and with electric fans on cars having electric transmissions.

Passenger Accommodations—Seat spacing varies from 26 in., the almost universal practice being to use 3-2 spacing. There is usually one saloon with dry hopper per car.

Table 2—Performance Data

Road	Per Cent Serviceable Days		Miles Per Total Failure	
	Mechanical	Electrical	Mechanical	Electrical
Baltimore and Ohio	....	....	......	......
Boston & Maine	74	....	......	......
Canadian National	95.3	*81.7	......	*9,112
Central Vermont	....	96	†15,000	......
Chicago, Burlington & Quincy	87	....	......	......
Chicago Great Western	86	94	9,576	17,207
Chicago, Milwauke & St. Paul	....	....	......	......
Chicago & North Western	66	....	......	......
Erie	79.1	95.4	......	......
Great Northern	....	....	......	......
Lehigh Valley	87.7	97.6	15,951	No failures
New York, New Haven & Hartford	73.3	93.1	11,570	38,900
New York Central	83.4	....	6,555	......
New York, Ontario & Western	....	....	......	......
Northern Pacific	....	....	......	......
Pennsylvania	85.7	91.4	24,070	48,235
Reading	94.5	83.6	2,873	8,722
Seaboard Air Line	....	....	......	......
Southern Pacific	70.5	....	37,428	......
Union Pacific	89.1	....	22,724	......

*Diesel Electric. †Storage battery.

Hot water heaters are almost universally used in preference to hot-air type though cars vary so greatly in insulation, use of double windows, location, etc., that the amount of radiating surface varies considerably. Aluminum and finned steel or copper tubes are used to reduce the weight of the system in some cases.

Vacuum fuel feed systems predominate, but a number of cars use air pressure on the main tank, while others use a mechanical pump feeding a gravity tank, with an overflow return to the main tank, and some automatic electric pumps are being tried out. There is room for further development in means for insuring reliability of fuel feed and the removal of foreign matter.

Life of Equipment—There is some divergence of ideas regarding the possible life of rail car equipment, and also in regard to the allowances made for this in accounting. It seems to be generally agreed that the car is good for some 20 to 30 years, the power plant 10 to 15 years, mechanical transmissions estimated at from 5 to 10 years, and electric transmissions from 10 to 25 years. Few of the railroads in question, however, have been using equipment a sufficient period of time to speak with authority on this point. The following statement from one of the pioneer railroads on the use of rail cars is, however, highly significant.

This railroad has cars which have been in daily operation for 20 years, and are now in practically as good condition as when put into service. Of 29 cars now operating, two have been in service nearly 21 years, five nearly 20 years, and all but 10 have been in service over 15 years.

The mileage performance over the total number of years would be difficult to ascertain, but it is a fact that most of our cars have passed the million-mile total, with some of them well along in the second million cycle.

Seven of the original 10 motor cars have been removed from service. These, however, were built during the early experimental days of the rail cars, and were of a different construction from those produced a short time later. The matter of obsolescence has not affected our cars as minor changes have been made from time to time, bringing them up to date although these changes have not disturbed the original construction more than superficially.

Class of Service—The majority of the railcar operations are in branch line service, although several of the western railroads use single cars on main line local work. The double power plant cars operating with two and three trailers on the Seaboard and Lehigh Valley lines also handle main line local traffic.

The daily average mileage of all schedules submitted is 148 miles per day per car. The longest daily mileage shown on several railroad runs between 300 and 400 miles, although on the eastern railroads figures in excess of 200 miles per day are rare.

With very few exceptions, the rail cars are used to replace, rather than to supplement or extend steam service. In many cases rail cars permit continuing runs which otherwise would have to be abandoned.

Crew Assignment—Three railroads report a normal crew of three on a single car. Other railroads report two men, this as the usual crew on a single car with an occasional third man when the baggage is heavy. When one trailer is hauled, several railroads operate occasionally with a two man crew, but the normal crew on a single car and trailer is three men. Three railroads report four-man crews on this combination of equipment when the baggage is heavy or when operating in main line service.

Costs—Typical operating costs of rail car equipment are set forth in Table 1. It has been necessary in some cases to condense and group items in order to permit ready comparison. Obviously the age of the cars and the average daily mileage must be given due consideration in making comparisons.

Fuel—A large majority of rail cars are using commercial gasoline fuels which run slightly better than government specifications, the cost varying between 13 cents and 21 cents per gallon, with an average of 18 cents.

Considerable interest has been shown toward the possibility of utilizing the cheaper low-grade fuels such as distillate and Diesel oil.

The Southern Pacific is using a mixture of one part gasoline to two parts of distillate. The Union Pacific has satisfactorily used straight distillate for a number of years, mostly in large-sized, low-speed engines, this being accomplished through the use of individual carburetors of special design for each engine cylinder. Several other railroads have experimented along these lines with various degrees of success.

The Canadian National has done pioneer work in applying Diesel engines to rail cars and is realizing very satisfactory economies, not only in the cost of fuel per gallon, but in the utilization of this fuel in their engines, securing an unusually high mileage per gallon.

Performance Data—There seems to be considerable variation in the methods of recording performance on various railroads, especially with respect to the measure of reliability in terms of miles per detention and miles per total failure. The returns of such information have been gone over and the figures which appear to have been arrived as on a comparable basis are shown in Table 2.

Maintenance—Inspection—Instruction—Replies regarding the organization used for maintenance and inspection of cars have been rather meager due in some cases to the fact that the use of rail cars in usually not of long standing and that no routine shopping methods have been evolved. In most cases, the repairs are apparently taken care of directly where the cars tie up, while on a few railroads, special shops have been equipped into which rail cars are run for heavy overhaul work. Inspection is usually taken care of by especially qualified gasoline engine men in connection with the local maintenance forces. The instruction of operators in the case of newly-acquired equipment is by the manufacturer's representatives, and thereafter by the gas rail car inspectors or road foremen. It is agreed that a thorough education of personnel and the efficient and smoothly-working organization constitute most important factors of the rail car problem.

Public Opinion—The expressed public opinion is almost uniformly favorable, although in the case of some antiquated equipment, which has proved unreliable in service, public opinion has been adverse—or, merely tolerant. It appears that the public is much more favorable toward the large cars which appear more like regular equipment, and in which case the rather rough operation of gears and clutches has been eliminated by the use of electric drivers.

Scope of Application—The replies to the questionnaires are rather non-committal respecting the possible scope of application of rail cars, and in general refer directly to the present application of rail cars on the respective lines, so that railroad operating only single cars on branch lines express themselves as believing that this is the only suitable application, whereas railroads which have operated large cars with single or multiple trailers in main-line local service seem to consider this a satisfactory application.

Although in Table 1, it is shown that the direct operation expenses of gas rail cars are distinctly less than those of branch lines steam service, this does not constitute the entire saving, for by the use of automotive equipment it has frequently been found possible to avoid the expenses due to the maintenance of coaling and water stations, turn table, ash pits, etc., and in many instances it has permitted the rearrangement of runs and the concentration of facilities in relatively few modern enginehouses and the closing up of small outlying houses, or limiting their use to more shelters for gasoline equipment. In some other cases, due to the double-end operation of electric cars, the turning of locomotives, and the numerous incidental switching operations have been eliminated permitting economies in forces and shorter terminal layovers. The actual values of these somewhat intagible savings are not easily obtained, but they are not inconsiderable and it is probable that as railroads become more familiar with the possibilities of the rail car they will find increasing opportunities for their beneficial and economical use, as there is a larger field for rail cars than that which has been emploited.

This report is signed by C. E. Brooks, Chief of Motive Power, Canadian National Railways; B. N. Lewis, Mech. Supt., Minneapolis, St. Paul & Sault Ste. Marie Railway; F. P. Pfahler, Asst. Eng., Pennsylvania Railroad; A. H. Fetters, Mech. Eng., Union Pacific Railroad, and D. L. Bacon, New York, New Haven & Hartford Railroad, the members of the committee.

Report on Motor Transportation

By F. J. Swentzel, Mechanical Superintendent, New England Transportation Co.

Our company, which was organized in Massachusetts on June 15, 1925, and which started operations August 10, 1925, anticipates for the year ending December 31, 1927, operating about six million motor coach miles, carrying about four million people at a cost of about 29 cents per coach mile, which would include all costs.

This mileage will be run off on 43 routes, inluding six summer routes and will involve over 190 motor coaches, 13 automobiles and 4 trucks—total number of units, 207.

Of the 190 motor coaches, 74 are the four-cylinder type and 116 are the six-cylinder type; 50 are semi de luxe cars and 140 de luxe cars:

The four-cylinder coaches are used for handling the shorter local traffic and the six-cylinder parlor cars are used for the longer haul routes. A considerable percentage of our service is run in place of or auxiliary to the New Haven steam railroad service and this service in itself effects a considerable saving to the New Haven railroad in lieu of steam service and in itself justifies the operation. In addition to this saving, we are in position, we hope, to earn a net this year independent of the above.

In addition to the regular operation of the schedule which we cover, we in our own territory reach out for and are getting considerable so-called "party business" covering movement of special parties to and from cities within our steam railroad limits. This business is attractive as it has a tendency to utilize our surplus equipment, which is necessary for us to have to cover peak load days on Saturdays, Sundays and holidays and which can well be utilized for special party business on the first five days of the week. Our present tariff covering this service is 50 cents per mile for revenue mileage and 30 cents for necessary deadhead mileage with four hours free turnaround time after which we receive $4.00 an hour for waiting; the minimum charge for special party service is $30.00.

Our chartered coach miles in 1926 were about 92,000 miles and we anticipate doubling this mileage in 1927.

While the steam railroads and the trolleys have a function of their own, there is in and around New England a very large percentage of local travel, for one reason or another, who desire motor coach service and patronize it freely, thereby creating a very fertile field for this class of service on the highway and with particular reference to service between cities and towns approximately 50 miles apart.

There is also a considerable demand for the so-called special party business in and around New England covering seashore resorts and the mountains during the summer. This is particularly true in metropolitan Boston, which area includes a 50-mile radius and which has a population of approximately two million people.

We believe the service is one of public necessity and that it will increase, as in many cases it provides the only service which some of the smaller towns have. Railroad stations and trolley service are frequently some miles distant from the town activities. This highway service has a tendency, in our opinion, to build up rural communities and also has a tendency to create both additional and better highways.

The number of motor vehicles on the highways has increased very rapidly during the last 25 years until this business is one of the biggest in the country today involving approximately twenty-five billions of dollars if the highway improvements are included. It seems to me that this speaks for itself so far as the effect of motor coach operation is concerned.

As with the steam railroad, the earning power of a transportation company depends largely upon the efficiency of its power. There is nothing, in our opinion, that will reduce the net income quicker than poor or deferred maintenance. In taking up the maintenance problems of a fleet of motor coaches or trucks, I wish to call your attention to a very important factor, which will have a great bearing on a successful and economical operation.

Make a very careful and thorough study of the physical characteristics of the territory through which the routes are to be operated, so that you will be able to select the coach or truck equipment best suited for your operation. This can very easily be accomplished with the information you can secure from the carriers now operating coaches and through unbiased engineering advice, which is possible to secure; consequently, careful consideration should be given to the selection of your equipment, for your success will greatly depend on this. No amount of good management or skillful maintenance can result in unqualified success if your equipment is unsuitable or poor.

Before your actual operations begin, you should organize and equip a mechanical facility for the purpose of maintaining your fleet from the beginning. Do you allow yourselves to go into deferred maintenance, as you all know it is very expensive and requires a great amount of unnecessary work to put the equipment back in good mechanical condition.

Regardless of the physical conditions of the operation, I do not think it necessary to purchase more than two different types of coaches. With trucks, one make with a range of capacity from 1½ tons to 5 tons with trailers of 10 tons capacity for terminal transfer jobs.

The purpose of calling your attention to the advisability of standardizing on the least possible makes of units, is for two reasons: first, the difficulty of being able to stock parts economically. The more makes and motors you have, the greater the difficulty in this respect. Second, the modern motor coach is less than four years old and mechanical improvements, which are being developed by the different manufacturers, are at a very rapid rate, so much so that it is almost impossible to keep up with them. For instance, a comparison of the first ten coaches delivered to us a year ago last December and the last ten, with a period of only ten months having elapsed between these delivery dates, would cause you to doubt that they had been manufactured by the same company.

Where an operating company is compelled to route its coaches through two or more states, it is confronted with a very serious problem in endeavoring to comply with the large and varied number of laws enacted, covering the public utilities and motor vehicle commissions; therefore, it is more than advisable to secure the services of an expert and qualified automotive man to inspect the chassis and body construction as they are being built, so that they will meet your specifications and the requirements of the different state laws when they are delivered to you. Up to very recently we did not have one piece of equipment delivered to us, which we could place in service, without a great number of changes and improvements being made by us.

A very important fact in economical maintenance is the protection of your equipment from abuse and mishandling by the coach operators. To best overcome this, a prospective operator should be turned over to the mechanical department by the operating superintendents, after he is qualified for employment, with a view of ascertaining if the applicant is able to judge speed and distance well enough to operate a motor coach or truck safely (the handling of both are very similar). After he proves to us that he is capable in this respect, he is placed in school under a capable mechanical instructor, not with the idea of making a mechanic out of him, but to acquaint him with the general construction of a unit, what damage is done by improper handling and how to make minor road repairs, such as locating a defective spark plug, bad electrical contact and the replacement of burnt-out electric bulbs. If the operators are able to take care of these minor troubles, it saves a great many unnecessary trips with the service cars.

It is quite difficult to secure all round automotive mechanics, as men of this type are few and far between. Another feature in connection with transportation which has a tendency to interfere with securing mechanical help, is the fact that it is a seven-day job. In the organization of our shops in Providence, I endeavored to eliminate the all round mechanic by employing men who have specialized in one particular branch of the industry.

As to the shop organization at Providence, I have laid it out covering two departments, or I might say two different classes of work. The back shop men, who work six nine-hour days a week and over the machine, body, paint, blacksmith and welding jobs and the other men, whose duties are general servicing and running repairs, who work nine hours a day seven days a week covering 24 hours a day. This layout also has a tendency to facilitate the work in the auditing department pertaining to labor classification and the difference between running repairs and servicing and major and general overhauling.

The complete personnel of the main shops at Providence consists of one chief clerk, one secretary clerk and two stenographer-clerks in the superintendent's office. In the shop proper:

1 general foreman
3 assistant foremen
16 first class mechanics
7 second class mechanics
4 painters
3 body workers
1 welder
1 chauffeur
1 blacksmith
3 firemen
2 machinists
4 helpers
2 greasers
2 electricians
2 inspectors
3 washers

This gives a total personnel of 58, with a storekeeper and three clerks in the stores looking after the equipment.

The machine tool equipment is complete in every detail. We can machine any part of a motor vehicle: we regrind our cylinder blocks, crank shafts, cam shafts, pistons and piston rings. Our electrical department takes care of all our generator, starter, magneto and battery repairs as well as battery charging. We make all body repairs, both metal and wood handling, blacksmithing in all its branches, except spring repairing; our spring breakage is so small that it would not be economical to operate our own spring shop. The paint shop has a capacity of three jobs in eight days. These shops take care of approximately 143 coaches, including major overhaul and servicing.

We are painting our coaches by hand, using a maroon shade of enamel. It requires more time to paint by hand, but we are convinced that it is the most satisfactory way of applying enamel.

Question of Standardization

We have drawn up our own body specifications, covering both de luxe and semi de luxe types of body, embodying the features best suited for our particular operations and covering in every detail the requirements of the public utility and motor vehicle commissions in the states in which we operate. This also gives us one more standardization, something that is very desirable for a number of reasons, the most important of which is a more economical maintenance.

We have also a set of specifications covering the chassis and compel the manufacturer to comply with them, except where it might have a tendency to interfere with the general design of his unit.

Another problem, which confronted us in our operation, was brakes. We were continuously involved in any number of arguments with the state authorities over the lack of efficient brakes. There was also the danger to lives and property, which we were anxious to eliminate. After considerable experiments, we replaced defective brakes, with the installation of Westinghouse air equipment and eventually will use a metal to metal brake. Other than a few minor troubles, and these we have remedied, we are satisfied that it is the proper brake equipment for both coaches and heavy duty trucks.

We have had developed by the Corbin Company a speedometer head without the odometer mechanism, which gave the company more space in the head to perfect an accurate speed indicating instrument. This instrument has two hands on the dial, one of which shows the actual speed being maintained and returns to zero when the coach is not in motion; the other remains at the point of maximum speed attained. These are checked at the terminals at the end of each trip. If it shows a speed of more than 30 miles per hour had been reached, it is reported with the operator's name to his superintendent, who in turn takes what action he deems necessary for disciplinary purposes. Our speed rule makes it a punishable offense if he exceeds 30 miles per hour. The head of the instrument is locked and requires the use of a key to reset the maximum speed hand back to zero. These instruments are also sealed, and between the lock and seals, it is impossible for anyone to reset them without the use of a key and plunger.

We have at all large terminals mechanical department employees, whose duty it is to inspect all arriving coaches, covering motor, motor oil level, tires, steering gear, brakes, lights and body damages. We also inspect every coach nightly after it has been turned over to us by the operating department. This inspection covers all parts, which should they fail to function properly, would cause a road failure or accident, general condition of the motor, bodies, lights, oil level and includes checking up for oil change and greasing mileage. The value of both the terminal and nightly inspections is the best shown by our records for the Saturdays, Sundays, and Mondays of Memorial, Independence and Labor days of last year. We went through these nine days of peak load holidays without a mechanical road failure. We have had a few accidents caused from defective parts, not detachable by inspection, but we have not had one which could be caught by inspection.

The manufacturers of motor coaches need educating in what is best suited for a safe and economical operation, and I am more than confident that the carriers with the assistance of their automotive engineers are best qualified to do this. To give you an idea of what I mean, I might take up the filling of coaches with gasoline. Our coaches all have tanks of 50 gal. capacity and the filler pipes are so small in diameter that it takes from five to twelve minutes to fill the tanks. This causes overflow waste of gasoline on the ground and it also interferes gready with the maintenance of our schedules.

Maintaining a fleet of motor vehicles is quite a problem when they put up at your own garages, but it develops into a much greater problem when your fleet is scattered from Provincetown on Cape Cod to the eastern boundary of New York State, relying on another subsidiary of the New Haven at four points, 25 public garages and shops at other tie-up points, with our own eight shops to service and keep in repair our fleet. This requires a great deal of mechanical supervision that would not otherwise be required.

Mileage of Buses for Lubrication and Repairs

There is a great difference of opinion in regard to the proper greasing of the chassis and renewal of crank-case oil. We have given these conditions very careful study and after thorough tests we adopted the following: We grease universal joints and steering gear parts at 500 miles; the complete chassis at 1,000 miles; a complete crank-case oil change at 1,500 miles.

There are at least two practical oil filters on the market for unit installation that are not only practical but will, I am sure, triple our present oil mileage when we are in a position to install them. I have made a careful study of oil reclaiming operations and I am convinced that nothing is to be gained by using them in their present stage of development.

Another question which comes up from time to time is what mileage when we period should a coach or truck be given its major overhaul and when should maintenance cease and replacement take place. In the first place, it is impossible positively to fix the replacement period, for replacement of parts takes place in a great majority of cases before the unit has covered any great mileage. The proper general overhaul, including replacement, can only be governed by the physical characteristics of your operation and the service required of the units and if they are being furnished with the proper grade of oil and lubrication.

I am sure that 85,000 miles, under normal conditions, is about the proper period that may be figured on for the first major overhaul. This major overhaul, including the reboring of blocks with, of course, oversize pistons and rings to fit; replacement of bearings in some particular makes of units and in some cases new timing gears, the regrinding of crank-shafts and the refacing of valve seats and general overhauling of the electrical equipment, with, in most cases, replacement of parts.

If a coach which has been shifted to an isolated point has had a major overhaul, or in other words had work done on it, which takes it away from the manufacturer's standardization and that coach breaks a piston or burns out a bearing and we at Providence are called upon to furnish this part, we must be in a position to send them a part that may be fitted with the least amount of labor; consequently, it requires us to keep a complete record in my office of what work has been done on every job, covering the size of rebore of cylinders, regrinding of crankshafts, the out of place alinement of the crank-shaft, to take care of the replacement of timing gears, etc.

I wish to take up a very important factor in connection with successful motor maintenance and that is, proper grade of oil to be used. It is impossible for an operating company on the Atlantic Seaboard to recommend the proper grade of oil to a company operating the same make of units in another territory; this you must work out for yourselves. We have coaches of the same make and model operating in two territories under different conditions and remote from each other, and we secure better results by using two different grades of oil.

I have had the question put up to me as to which was the best grade of gasoline. This is also a question that will be necessary for you to work out yourselves. One make of gasoline will give better results in the same make of vehicle in one territory than in another and work out just the opposite in different types of vehicles.

Owing to the great area covered by our operation, and owing to the fact that we are trying up at a great number of isolated points, it was necessary to develop a system of records and reports so that we could check up on the companies at these isolated points doing mechanical work and servicing for us; this we have accomplished, I am more than confident, for it is impossible for a unit to go over its greasing or oil change period more than 24 hours before we catch it. If a unit goes by these periods and does not show up on the daily report, we get in telephonic communication with the company involved informing them of the fact and follow it up with a call from a member of the mechanical supervision to see that our instructions are complied with.

Our whole operation in regard to tires is being run on a guaranteed mileage basis, the contracts being signed with the Fisk Rubber Company covering the Rhode Island and Massachusetts divisions and the United States Rubber Company covering the Connecticut division. I am not qualified to give you the figures on our tire mileage, especially at this time, for the mechanical department does not handle these figures, and for another reason, we have not done the mileage where the figures would be of advantage to you, but from my personal observation, I feel sure that regardless of the fact that motor coaches are undertired, you should get from 18,000 to 26,000 miles out of your tires.

The back shops of The New England Transportation Company at Providence will take care of the major overhauling of the internal combustion engines of the gas railcar equipment of the New Haven Railroad system.

Trunnion Type Air Dump Car

The Pressed Steel Car Company through their subsidiary, the Koppel Industrial Car & Equipment Company, have during the past year added to their line of Koppel air dump cars a new trunnion type car as herein illustrated to meet particular conditions for which this type of car is best suited. This car is being produced in cubical capacities of 27 and 30 yards level full, or 36 and 42 yards heaped and of 100,000 lb. capacity, but can be furnished in other capacities to meet special requirements.

Some of the particularly attractive features of this car are as follows:

Low center of gravity—7 ft. 6 in. high overall from top of rail, permitting quick inexpensive maximum loading with steam shovel or crane, making car very attractive for ditcher service and well adapted for smooth riding on temporary tracks;

Quick clean discharge of lading 7 ft. from center of tracks, which is especially valuable for ditcher service as the load not only clears the ties but also is distributed well out over the ballast;

Dumps to either side without changing any parts; dumping operation controlled by hand operated valves located at one or both ends of car;

Can be locked instantaneously so that car cannot be dumped until lock is released. When lock is released, car will only dump to one side as desired and not to other side until lock is reset.

The door operating mechanism located at ends of car, no operating parts along the side of car to become damaged in dumping.

The complete elimination of body locking devices.

The car body quickly moved to dumping position and returned automatically by gravity after dumping to normal position without any shock to car.

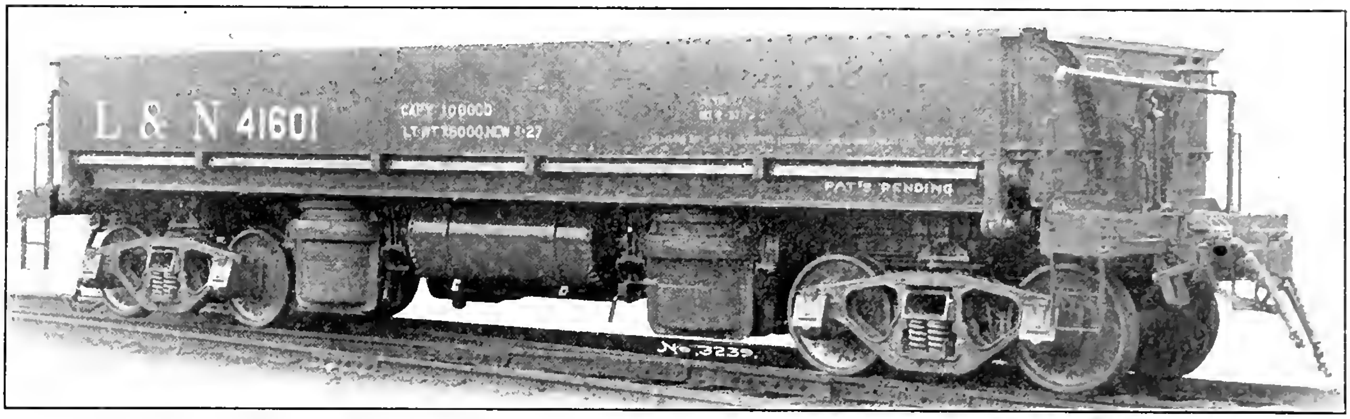
The illustration shows one of the twenty 27 cu. yd. cars were delivered a few months ago to the Louisville & Nashville Railroad Company and are now in service on that road. These cars are of very sturdy construction, built of steel throughout. The body is built in a separate unit with ½ in. floor plate supported intermittently by means of cross beams as to leave no area unsupported. The body when in load carrying position is supported by eight trunnions placed four on each side of the car, resting in a like number of sockets, thus providing exceptional rigidity resembling in this respect a gondola car. The underframe center construction is composed of heavy steel channels with heavy top and bottom steel cover plates—a rugged steel structure framed into the center construction carries the dumping cylinders and trunnion sockets. Body bolsters are composed of double course pressed steel diaphragms with top and bottom cover plates.

Four telescoping type cylinders, two on each side of the car are provided, which obtain their air from a storage reservoir placed between two of the cylinders. Dumping is accomplished by turning the handle of the operating valve located at one end of the car conveniently placed for easy handling, and by virtue of a special design of control valve any car in a train may be dumped individually, also a whole train of cars may be dumped either from any one car or from the locomotive. An "indicator" provides simple means of determining side of discharge and when placed at the desired position, a three way valve located near center of frame is set automatically and controls the flow of air from reservoir to the cylinders opposite the dump side, and also cuts off the air supply to the two dormant cylinders. All four cylinder piston rods are permanently connected to pins attached to frame of car body, which permits the two active as well as the two idle cylinders to swing in their respective sockets during the dumping operations.

As air is released from the reservoir to the two cylinders on the side opposite the desired side of discharge, the body is gradually raised with the low or discharge side resting in the four trunnion sockets on dump side serving as pivots. When one side of the body ascends, the door on the discharge side is permitted to lower itself since its automatic action is mechanically controlled by levers and serves as an apron for distributing the lading away from the track and in special cases as a plow or spreader when the empty car is hauled away. By means of an exhaust or bleed valve which is automatically set in action when handle on operating valve is returned to running position, the used air is gradually released from the cylinders, thus allowing the body to descend to its normal load carrying position without shock.

The Pressed Steel Car Company are now manufacturing Koppel Air Dump Cars of this type for the New York Central Lines, Pere Marquette Railway and Great Northern Railway, and have recently furnished air dump cars of various types to the Baltimore & Ohio, Gulf, Mobile & Northern, Mobile & Ohio, Missouri Pacific, Southern Railway, Montour Railroad and Great Northern Railway. These cars are also being used on several of the important railroads by railroad contractors.

The car illustrated in this article represents the Koppel Trunnion Type car with double plate sides, hinged to body side sills and operated from the ends only. For general service where a lighter constructed car is desired, this type of car with single plate sides or doors is recommended, the sides being hinged to body side sills and operated by a series of levers located underneath the body.



Trunnion Type Air Dump Car in Service on the Louisville & Nashville Railroad

Mine Haulage Locomotive Is Most Powerful Ever Built

A marked advancement in the development of electric mine locomotives for main haulage was represented by the new 20-ton Baldwin-Westinghouse locomotive recently completed for the Bertha-Consumers Company.

It is the most powerful locomotive of its type ever built, having a total capacity of 300 horsepower supplied by two motors which is unequalled in mine motor capacity for two-motored units.

The mechanical features of the locomotive include bar-steel side frames located outside of the wheels, and held to the end frames by driven through-bolts in reamed holes, forged steel axles, steel-tired wheels, semi-elliptic leaf springs, Timken tapered roller journal bearings for driving wheels, automatic locking screw type brake, straight air brake, four sand boxes arranged for air operation, an air whistle and a special space provided for carrying a rerailer iron.

The two motors are 250-volt, commutating-pole type connected to the 6-in. axles with single reduction, 5 in. face, 2½ D.P., helical solid forged steel, heat-treated B.P. grade gearing. The motors are inside-hung and spring-supported from the lower half of the motor frame. All bolts holding the motor frames together are through-bolts, and each axle cap is held to the lower half of the motor frame by four large through-bolts. The gear case of the motor has a two-point suspension and is supported by bracket arms extending from the motor housing and the motor axle cap. The motor armature is supported on Timkin tapered roller bearings.

The master controller case will house the accelerating control drum and the manually-operated reverser. The accelerating drum will have control of the air-operated contactors located at the rear end of the locomotive, providing what might be termed a semi-electro-pneumatic, series-parallel control.

The semi-electro-pneumatic control carries the main circuit through the reverse drum of the master controller. The interlocking of the accelerating drum with the main drum prevents making or breaking the connections on the reverse drums while they are carrying current. The main drum or accelerating drum carries only control current and controls the operation of the accelerating electro-pneumatic contactors or unit switches which make and break all main circuits. Overload protection is provided to the main motor circuits by an overload relay which functions on a predetermined current setting causing the electro-pneumatic switches that act as line switches to open the circuit. The control circuit is provided with a manually-operated canopy type control switch which is also fused. The headlight circuit is provided with a three-way fused switch so that either the front or the rear arc headlight can be turned on as desired.

The principal dimensions of the locomotive are:

Track gauge—42 in.
Wheel base—80 in.
Width over trolley socket—67½ in.
Width overall and over bumpers—72 in.
Height overall excluding trolley pole—45 in.
Length excluding bumping block—17 ft. 4 in.
Wheel diameter—36 in.

The nominal rating of the locomotive is 10,000 lbs. drawbar pull at a speed of 8¾ miles an hour with the motors operating in parallel.

On level track the locomotive will be capable of starting and hauling a 400-ton train. On a 1 per cent grade the locomotive will be capable of starting and hauling a 275-ton train.

Notes on Domestic Railroads

Locomotives

The Illinois Central Railroad has ordered 15 eight-wheel switching locomotives from the Baldwin Locomotive Works.

The Norfolk & Western Railway will build 30, 18,000 gallon tenders at its own shops at Roanoke, Va.

The Lehigh & New England Railroad is inquiring for 6, eight-wheel switching locomotives.

The Alabama State Docks have ordered from the America Locomotive Company one six-wheel switching locomotive.

The Great Northern Railway is inquiring for 10 electric locomotives to be of the 2-6-6-2 type.

The Chicago & Illinois Midland Railway has ordered from the Baldwin Locomotive Works 2, 4-4-0 type locomotives.

The Chicago, Springfield & St. Louis Railroad is inquiring for two freight locomotives.

The Delaware, Lackawanna & Western Railroad has ordered 10, three-cylinder Mountain type locomotives and 5, 4-8-4 type locomotives from the American Locomotive Company.

The Peruvian Government has ordered 2 Mikado type locomotives from the Baldwin Locomotive Works.

The Great Northern Railway is constructing 4 locomotives in its own shops.

The Chicago North Shore & Milwaukee Railroad has ordered 2, 65-ton electric locomotives from the General Electric Company which will operate either from a trolley or from the storage batteries which they carry. The storage batteries, which will be charged from the trolley, are being furnished by the Electric Storage Battery Company.

The Duluth, Missabe & Northern Railway has ordered 4, ten-wheel switching locomotives from the Baldwin Locomotive Works.

The Central of New Jersey has ordered 5, Pacific type locomotives and 10 eight-wheel switching locomotives from the Baldwin Locomotive Works.

The Erie Railroad has ordered 80 locomotives as follows: 30, eight-wheel switching locomotives from the Baldwin Locomotive Works, 25, 2-8-4 type from the Lima Locomotive Works and 25, 2-8-4 type from the American Locomotive Company.

The Peoria & Pekin Union Railway has ordered 3, eight-wheel switching locomotives from the Baldwin Locomotive Works.

The Peoria & Pekin Union Railway is in the market for 3, eight-wheel switching locomotives.

The Youngstown & Northern Railroad has ordered 2, six-wheel switching locomotives from the American Locomotive Company.

The Gulf, Mobile & Northern Railroad has ordered 4, Decapod type locomotives from the Baldwin Locomotive Works.

The Lehigh & New England Railroad has ordered 3 light type eight-wheel switching locomotives, 3 heavy type eight-wheel switching type locomotives and 2 Decapod type locomotives from the Baldwin Locomotive Works.

The Usina Junqueira, Peru, South America, has ordered one consolidation type locomotive from the American Locomotive Company.

The Kansas, Oklahoma & Gulf Railway has ordered 5, 2-10-2 type locomotives from the Baldwin Locomotive Works.

Passenger Cars

The Seaboard Air Line Railway is inquiring for 10 to 12, gas-electric combination passenger and baggage cars, 10 to 13 gas-electric baggage cars and 24 trailer cars.

The Norfolk & Western Railway is inquiring for prices on the construction of 25, 60-ft. all steel mail storage cars.

The Central Railroad of New Jersey has ordered 25 coaches from the Bethlehem Steel Company.

The Chicago Milwaukee & St. Paul Railway is inquiring for 10 gas-electric combination passenger and baggage cars.

The Chicago, Burlington & Quincy Railroad is inquiring for 4 lounge cars.

The Chicago & Illinois Midland Railway has ordered 6 passenger cars from the Pullman Car & Manufacturing Corporation.

The Great Northern Railway is inquiring for 10 passenger car underframes.

The Reading Company is inquiring for 2 baggage-horse cars, and also for 15 steel baggage cars.

The Paulista Railway of Brazil has ordered 3 parlor cars, 2 chair cars, 2 mail cars, 7 first class coaches and 6 second class coaches from the American Car & Foundry Company.

The Atchison Topeka & Santa Fe Railway has ordered 3 parlor cars from the Pullman Car & Manufacturing Corporation.

The New York, New Haven & Hartford Railroad has ordered 20 baggage cars from the Osgood Bradley Car Company.

The Reading Company is inquiring for 15 steel baggage cars.

The Delaware, Lackawanna & Western has ordered 20 mail cars from the Standard Steel Car Company, 10 express cars from the American Car & Foundry Company and 2 combination mail and baggage cars from the Pullman Car & Manufacturing Corporation.

The Chicago, North Shore & Milwaukee Railroad is inquiring for 10, double end two-man passenger cars.

The Erie Railroad is now inquiring for 4 all-steel dining cars.

The Illinois Central Railroad is inquiring for 6 baggage and mail cars and 10 baggage and express cars.

Freight Cars

The Reading Company has ordered 500 gondola cars from the Bethlehem Steel Company and 500 from the Standard Steel Car Company.

The Chicago, Milwaukee & St. Paul is inquiring for 5 flat cars.

The Chicago & Illinois Midland Railway has ordered 4 caboose cars from the American Car & Foundry Company.

The Great Northern Railway will construct 800 box cars in its own shops.

The Western Pacific Railroad is inquiring for 40 dump cars of 30 cubic yd. capacity.

The American Refrigerator Transit Company will make heavy repairs to 160 refrigerator cars in its own shops.

The Cambria & Indiana Railroad has given an order for repairs to 300 hopper cars to the Pressed Steel Car Company.

The Fruit Growers Express has ordered underframes from the Ryan Car Company.

The Norfolk & Western Railway is rebuilding 50 all steel gondola cars of 90-ton capacity in its own shops at Roanoke, Va.

The Litchfield & Madison Railway is inquiring for prices on repairs to 247 gondola cars.

The Lehigh & New England Railroad has given an order for the repairs of 200 hopper cars to the American Car & Foundry Company.

The Minnesota Steel Company, Duluth, Minn. is inquiring for 6 dump cars of 30 cubic yd. capacity.

The Timken Roller Bearing Company, Canton, Ohio has ordered 3 gondola cars of 70-tons capacity from the Canton Car Company and 3, from the American Car & Foundry Company.

The Great Northern Railway is inquiring for 250 all steel coal cars of 70-tons capacity.

The Pacific Gas & Electric Company has ordered 6, 30 cubic yard extension side dump cars from the Clark Car Company.

The Fruit Growers Express has ordered 50 underframes from the Bethlehem Steel Company, and also 300 from the Ryan Car Company.

The Spokane, Portland & Seattle Railway has ordered 2 extension side dump cars from the Clark Car Company.

The New York Central Railroad has ordered 50 box cars of 55-tons capacity from the American Car & Foundry Company.

The Chicago & Illinois Midland Railway has given an order for making repairs to 240 gondola cars to the Ryan Car Company.

The Delaware, Lackawanna & Western Railroad has ordered 300 steel underframe box cars of 55-tons capacity from the American Car & Foundry Company and 200 steel underframe box cars of 55 tons capacity from the Magor Car Corporation.

The Chicago, Rock Island & Pacific Railway has ordered 100 underframes for ice cars from the Bettendorf Company, Bettendorf, Iowa.

The South Porto Rico Sugar Company has ordered 50 cane sugar cars of 30-tons capacity from the Magor Car Corporation.

The Chicago & Illinois Midland Railway has ordered 350 coal cars from the Pullman Car & Manufacturing Corporation.

The Illinois Central Railroad has ordered 500 gondola cars from the American Car & Foundry Company; 500 gondola cars from the Illinois Car & Manufacturing Company; 300 hopper cars and 500 box cars from the Pullman Car & Manufacturing Corporation; 500 automobile furniture cars from the General American Car Company; 700 hopper cars from the Standard Steel Car Company; 500 automobile furniture cars from the Pressed Steel Car Company; 500 box cars from the Mt. Vernon Car Manufacturing Company and 500 flat cars from the Bettensdorf Company.

The Union Pacific Railroad has ordered 6 automatic air dump cars from the Western Wheeled Scraper Company.

The Western Pacific Railroad has ordered 40 air dump cars from the Western Wheeled Scraper Company.

Buildings and Structures

The Union Pacific Railroad plans the construction of a car repair shed at Albina, Ore., to cost approximately $50,000.

The Atchison, Topeka & Santa Fe Railway plan the construction of a 40-stall reinforced concrete and brick roundhouse, a planing mill and lumber shed, a one-story apprentice school, a two-story brick locker building, a one-story office building and a brick ice house at Emporia, Kans.

The Pennsylvania Railroad has awarded a contract for the construction of a sub-station at Sunnyside yard, Long Island City, New York, to cost approximately $50,000.

The Chicago, Rock Island & Pacific Railway has awarded a contract for the construction of a six-stall brick addition to the roundhouse at Amarillo, Texas, to cost approximately $40,000.

The Atchison, Topeka & Santa Fe Railway plans the construction of 600,000 gal. reservoir and dam, also a four-track concrete coaling station at Galesburg, Ill.

The Baltimore & Ohio Railroad has awarded to the Ogle Construction Company, Chicago, Ill., a contract for the construction of a 200-ton four-track reinforced concrete coaling station at Akron Junction, Ohio.

The Duluth, Missabe & Northern Railway has awarded a contract for the construction of a two-story dispensary and hospital at Duluth, Minn., to cost approximately $40,000.

The Boston & Maine Railroad is planning the construction of two sidings, 85 car capacity for north and southbound traffic at Manchester, N. H.

The Missouri Pacific Railroad has awarded a contract to Fairbanks, Morse Company, Chicago, Ill., for the construction of a 450-ton reinforced concrete electric conveyor type coaling station to serve three tracks at Osawatomie, Kans.

The New Orleans Great Northern Railroad will soon ask for bids for the construction of a six-stall brick roundhouse, a yard office and other terminal buildings at Jackson, Miss.

The Chicago, Rock Island & Pacific Railway has awarded a contract to the Railroad Water and Coal Handling Company, Chicago, Ill., for the construction of a water treating plant at Marion, Kans., having a capacity of 500 gal. per min., to cost approximately $30,000.

The St. Louis-San Francisco Railway planned the construction of a 24-stall frame roundhouse at Yale, Tenn.

The Gulf Coast Lines has awarded a contract for the construction of a reinforced concrete steel, and brick freight station at Harlingen, Texas, at a cost of $57,000.

The Southern Railway has awarded a contract for the construction of a three-track reinforced concrete coaling station of 500-ton capacity at Anniston, Ala., to the Fairbanks, Morse & Company, Chicago, Ill.

The Oregon Washington Railroad & Navigation Company plans the construction of a 200,000 bushel grain elevator on the east bank of the Williamette river at Portland, Ore.

The Chicago, Springfield & St. Louis has awarded a contract for the construction of a six-stall roundhouse at Springfield, Ill., also the construction of a roundhouse and shops at Jacksonville, Ill.

The New York, New Haven & Hartford Railroad has awarded a contract for the construction of a central boiler plant at South Boston, Mass., to cost approximately $500,000 to H. R. Kent & Company, Rutherford, New Jersey.

The Pennsylvania Railroad has awarded a contract for the construction of an extension to an engine house at West Morrisville, Pa., to cost approximately $75,000.

The Southern Railway has awarded a contract for the construction of an office building at Danville, Va., to cost approximately $35,000.

Supply Trade Notes

B. A. Clements, heretofore President of **Rome Iron Mills, Inc.,** has been elected President of the **American Arch Company,** succeeding **H. B. Slaybaugh** who has resigned. **Lee Deutsch** has been elected President of Rome Iron Mills, Inc., succeeding Mr. Clements.

Walter H. Bentley has been appointed special representative, with headquarters at Chicago, of the **Railway Curtain Company.**

E. W. Davis, for five years representative of the **Westinghouse Air Brake Company** at Boston, Mass., has been promoted to the position of Southwestern Manager of that company with headquarters at St. Louis. Mr. Davis was graduated from Purdue University with the Mechanical Engineering class of 1902. After several years service with the Santa Fe and Burlington railroads, and a number of industrial concerns, including the Westinghouse Automatic Steam Coupler Company, he entered the employ of the Westinghouse Air Brake in 1908. He was first an Inspector, then Assistant District Engineer at New York. In 1919 he was promoted to Representative, Westinghouse Traction Brake Company, at that point. Since January, 1922, Mr. Davis has served as Representative at Boston, a place which he relinquished to assume the more important duties in the Southwestern District.

The American Malleable Castings Association, 2013 Union Trust building, Cleveland, Ohio, has changed its name to the **Malleable Iron Research Institute.**

H. A. Couse, a member of the law department of the **General Electric Company,** has been appointed general counsel of the incandescent lamp department, with offices at 120 Broadway, New York City. **Philip D. Reed** will be associated with Mr. Couse at his New York office. **F. H. Babcock,** of the central station department, has been designated as assistant to **Charles W. Appleton,** who was recently elected vice-president in charge of general relations with public utilities.

Walter L. Graser, sales engineer of the **Truscon Steel Company,** with headquarters at Omaha, Neb., has been appointed manager of the Tulsa, Okla., office.

G. E. Wearn has been appointed central station sales manager of the **Westinghouse Electric & Manufacturing Company,** and will be located in New York. Since joining the Westinghouse Company, eleven years ago, Mr Wearn has devoted his time to sales engineering work in the power department and central station division.

The Whiting Corporation, Harvey, Ill., has appointed

Brazelton, Wessendorf & Nelms, Inc., Houston, Texas, its sales agent for southeastern, Texas.

Robert T. Kent has been appointed general manager of the **Bridgeport Brass Company**, Bridgeport, Conn.

The retirement of **A. H. Moore** and the appointment of **S. H. Blake** as chairman of the standardizing committee of the **General Electric Company** has been announced by **E. W. Allen**, vice-president of engineering of the company. Mr. Allen's announcement follows. "Mr. A. H. Moore, after 39 years of faithful and effective service with the General Electric Company and its associated foreign manufacturing companies, will retire August 1, 1927, on account of ill health.

"Mr. S. H. Blake will succeed Mr. Moore as chairman of general and other standardizing committees, and will take over his duties."

William duPont, of Wilmington, Del., has been elected a director and chairman of the executive committee of the **Miller Train Control Corporation**, Staunton, Va.

The Austin Company, Cleveland, Ohio, has opened a branch office in the Dixie Terminal building, Cincinnati; **H. L. Cornelison**, until recently manager of the Miami office, is in charge of the new Cincinnati office. The territory covered by the Cincinnati offices includes southern Ohio, southern Indiana and Kentucky. The Chicago office of the Austin Company was removed to larger quarters at 510 North Dearborn street on May 1.

The Adams & Westlake Company, Chicago, has awarded a contract to the **Ralph Sollitt & Sons** Construction Company for the construction of a one and two-story plant at Elkhart, Ind.

E. R. Wyler, who has been connected with the Cleveland, Ohio, sales branch of the **Independent Pneumatic Tool Company**, has been transferred to the sales department at the general offices in Chicago. Mr. Wyler will have his headquarters at St. Paul, Minn.

D. P. Hess, manager of the Columbus, Ohio, plant of the **Timken Roller Bearing Company**, has been appointed assistant to the president, with headquarters at Canton, Ohio, effective June 1.

H. B. Chamberlain, assistant to president of the **Tuco Products Corporation**, New York, has been appointed vice-president.

A. L. Bliss, district sales manager of the southeastern territory of the **Buda Company**, with headquarters at Jacksonville, Fla., has been transferred to Atlanta, Ga.

Raymond Boiselle has been appointed Representive of the **Westinghouse Air Brake Company** at Boston, Mass., succeeding **E. W. Davis**, promoted to the position of Southwestern Manager. Mr. Boiselle received his Mechanical Engineering education at the University of Illinois, and early practical experience with the Missouri Pacific, Santa Fe, and Rock Island railroads. Entering the service of the Westinghouse Air Brake Company in 1912, he was employed in the Test Department until 1917. During the World War he served as First Lieutenant and Captain, Aerial Armament Division overseas, then re-entered the Westinghouse ranks as Mechanical Expert in the Southwestern District, where he remained until appointed Representative in the Pittsburgh District in 1923. From this position he was transferred to the Boston Office.

The Dayton Manufacturing Company, Dayton, Ohio, has opened a new office at 25 Church street, New York City, in charge of **Joseph Leidenger**, vice-president.

The Western Electric Company has organized a new manufacturing branch at its Hawthorne works in Chicago to be known as the Specialty Products Shop. Among its many functions are the building of microphones, vitaphone parts, audiphones, telegraph and railroad signaling apparatus, test sets and telephone heating coil elements. **Jay W. Skinkle**, formerly signaling sales manager of the **Graybar Electric Company**, has been appointed superintendent of this new branch.

The North American Car Corporation has opened a district office at Dallas, Texas, in charge of **R. W. Patterson**, formerly a representative in the export department at New Orleans, La.

The organization of renewal parts engineering work as a department with **A. L. Broomall** as manager of these activities at both the Homewood and the East Pittsburgh Works of the **Westinghouse Electric and Manufacturing Company** has been announced by **W. S. Rug**, Vice President. Mr. Broomall formerly held the position of renewal parts engineer.

C. L. Fortescue has been appointed Consulting Transmission Engineer. He will concentrate his attention principally upon more fundamental problems of electrical transmission lines in general and will have a consulting relationship with engineering in other departments.

A change in organization at the Westinghouse Derry (Pa.) works also was announced. **G. M. Barrow** has been appointed manager of engineering and **N. A. Whalberg**, formerly attached to East Pittsburgh office, has been placed in charge of engineering on transmission line fittings at Derry.

The Falk Corporation, Milwaukee, Wis., has opened an office at 122 South Michigan avenue, Chicago, in charge of **C. H. Thomas.**

F. H. Landwehr, secretary of the **Electric Auto-Lite Company, Toledo**, has also been elected president of the **Prest-O-Lite Storage Battery Corporation**, Indianapolis, Ind. **J. H. McDuffee**, general sales manager of the Prest-O-Lite Company, has been elected vice-president, while **J. B. Motley**, credit manager of Prest-O-Lite Company, has been elected secretary. **J. B. Fenner**, formerly associated with Price-Waterhouse Company, New York, has been elected treasurer.

The American Electric Switch Corporation, Minerva, Ohio, with an authorized capitalization of $1,000,000, has been incorporated. **J. C. Lewis** is president; **Arthur Koch**, treasurer, and **E. F. Pinoelhl**, secretary. The corporation will manufacture a varied line of safety switches, panels and switchboards.

A. O. Woerner, representative of the **Scullin Steel Company**, St. Louis, Mo., has been appointed assistant vice-president.

T. P. Gaylord, acting vice-president of the **Westinghouse Electric and Manufacturing Company**, has been elected president of the **Pittsburgh Chamber of Commerce** by the board of directors of that organization.

Mr. Gaylord was born in Shelby, Mich., on February 15, 1871. He attended the Allen Academy of Chicago as a preparatory school for his later years in university training, which were devoted to study at the niversity of Michigan, from which he was graduated with the degree of electrical engineer. Gaylord secured a degree also from the Armour Institute of Technology in 1895.

The Chicago World's Fair was starting when Mr. Gaylord went to work for the fair company as engineer of underground construction and he continued in that capacity from 1892 to 1893. Following the close of the World's Fair, Mr. Gaylord became assistant professor of electrical engineering at the Armour Institute, Chicago, serving there from 1893 to 1898. He was engineer of the Chicago Edison Company from 1898 to 1899 and took his first job with the Westinghouse Electric Company in July, 1899. In 1902 he was appointed district manager, with offices in Chicago, which position he occupied until his present appointment in August, 1914.

Mr. Gaylord is a director in the Pittsburgh Chamber of Commerce, a director and member of the executive committee of the Pennsylvania State Chamber of Commerce, a member of the American Institute of Electrical Engineers, Chamber of Commerce of the United States, Duquesne Club of Pittsburgh and the Pittsburgh Athletic Club.

Theodore F. Merseles, president of **Montgomery Ward & Co.**, Chicago, has resigned to become president of the **Johns-Manville Corporation**, New York, to succeed **H. E. Manville**, who will be elected chairman of the board. **George Whitney** and **Francis D. Bartow**, partners in **J. P. Morgan & Co.**, in addition to Theodore F. Merseles, have been elected directors of the Johns-Manville Corporation.

The Interstate Iron & Steel Company, Chicago, will construct a furnace building 129 feet by 145 feet at 11018 Burley avenue, Chicago, Ill.

Items of Personal Interest

Harry G. Clark, assistant to the president of the Chicago, Rock Island & Pacific Railway, has been elected vice-president, with headquarters at Chicago. He will be succeeded as assistant to the president by **Frank E. Walsh**, secretary to the president.

E. M. Jenkins, chief draftsman, car department, of the Delaware, Lackawanna & Western Railroad, has been appointed master car builder with headquarters at Scranton, Pa., succeeding **Peter Alquist**, deceased.

A. D. Hanley has been appointed superintendent of the Sonora division of the Southern Pacific of Mexico, with headquarters at Empalme, Son., Mexico.

H. B. Shoemaker has been appointed assistant superintendent and supervisor of track of the Valley branch of the New York Central Railroad, with headquarters at Dunkirk, Ohio.

William Landess, chief electrician in charge of electrical maintenance of the Chicago Union Station Company at Chicago, has been promoted to assistant mechanical superintendent with supervision over all mechanical and electrical matters.

H. A. Moynihan, superintendent of the Old Colony division of the New York, New Haven & Hartford Railroad, with headquarters at Taunton, Mass., has been appointed superintendent of the Providence division, with headquarters at Providence, R. I., succeeding **G. A. Poore.** **H. E. Astley**, superintendent of the Midland division, with headquarters at Boston, Mass., has been appointed superintendent of the Old Colony division, succeeding **Mr. Moynihan.** **J. J. Snavely**, superintendent of the Waterbury division, with headquarters at Waterbury, Conn., has been appointed superintendent of the Midland division, succeeding **Mr. Astley.** **R. O'Hanley,** assistant superintendent of the Boston division, has been appointed superintendent of the Waterbury division, succeeding **Mr. Snavely,** and **W. S. Carr** has been appointed assistant superintendent of the Boston division, succeeding **Mr. O'Hanley.**

F. E. Slater, chief clerk in the operating department of the Pacific Lines of the Southern Pacific Company at San Francisco, Cal., has been promoted to supervisor of transportation, with same headquarters.

The Rutland, Toluca & Northern Railroad has elected the following as its officers: **John R. Cox,** president; **Laura Cox,** secretary and treasurer; **John R. Cox, Jr.,** vice-president and assistant to the general manager. **H. P. Haley** has been appointed auditor and traffic manager with headquarters at St. Louis, Mo. All with headquarters at Toluca, Illinois.

L. A. Clapp, superintendent of the Iowa division of the Chicago & North Western Railway, with headquarters at Boone, Iowa, has been transferred to the Galena division, with headquarters at Chicago, succeeding **F. F. McCauley.** **Mr. Clapp** has been succeeded by **E. L. Henry,** assistant superintendent, with headquarters at Clinton, Iowa.

C. G. Sibley, superintendent of transportation of the Second division of the Atlantic Coast Line Railroad, with headquarters at Savannah, Ga., has been appointed general superintendent of the First division, with headquarters at Rocky Mount, N. C., succeeding **W. H. Newell.** **J. A. Wall,** superintendent at Waycross district, with headquarters at Waycross, Ga.

C. E. Spens, vice-president in charge of traffic of the Chicago, Burlington & Quincy Railroad, and **E. P. Bracken,** vice-president in charge of operation, have been elected vice-presidents of the Colorado & Southern Railway.

R. W. Cattermole, superintendent and chief engineer of the Tonopah & Goldfield Railroad, with headquarters at Goldfield, Nev., has been appointed general superintendent, with headquarters at the same point.

James J. Butler has been appointed superintendent of the Chicago & Alton Railroad with headquarters at Bloomington, Ill.

C. W. Brown, superintendent of the Lehigh & New England Railroad with headquarters at Bethlehem, Pa., has been appointed general superintendent, with headquarters at Philadelphia, Pa.

Eugene Decker, chief clerk to the purchasing agency of the Maine Central Railroad, has been appointed purchasing agent with headquarters at Portland, Me.

Edward T. Miller, general solicitor of St. Louis-San Francisco Railway, has been elected vice-president and general solicitor, with headquarters at St. Louis, Mo.

R. P. Gillham, vice-president of the Campbell's Creek Railroad, with headquarters at Cincinnati, Ohio, has been elected president, with headquarters at the same point.

M. F. Rolfe has been appointed assistant to the vice-president and general manager of the Maine Central Railroad with headquarters at Portland, Me.

George P. McNear, Jr., general manager of the Toledo, Peoria & Western Railway, with headquarters at Peoria, Ill., has been elected president, with headquarters at the same point, following the discharge of the receivership.

G. S. Goodwin, mechanical engineer of the Chicago, Rock Island & Pacific Railway with headquarters at Chicago, Ill., has been appointed assistant to the general superintendent of motive power, with headquarters at same point.

V. L. Nelson has been appointed acting valuation engineer of the Ohio Central Lines, of the New York Central Railroad succeeding **H. F. Schryver.**

J. L. Bracken, engineering assistant of the New York, New Haven & Hartford Railroad with headquarters at New Haven, Conn., has been appointed assistant to the mechanical superintendent of the New York Division with headquarters at New York City.

Earle E. McCarty has been appointed superintendent of the Albuquerque division of the Atchison, Topeka & Santa Fe Railway with headquarters at Winslow, Ariz.

Obituary

George E. Parks, Mechanical Engineer of the Michigan Central Railroad with headquarters at Detroit, died of peritonitis following an operation for appendicitis at Harper Hospital on Sunday, May 15.

Mr. Parks was born on May 3, 1870, at Bedford, Indiana. He received his early education in the schools at that place and entered Purdue University, from which he graduated as Mechanical Engineer in 1892. After graduation he entered the service of the Grand Trunk Railway at Port Huron, Mich., as a special engineer, working with this Company until May, 1897, at which time he entered the service of the Michigan Central at Detroit as draftsman and apprentice instructor. He was appointed Mechanical Engineer in June, 1900, and transferred to Jackson, Michigan, as Master Mechanic in July, 1906. He held this position until August 1, 1910, when he left the service of the railroad for two years, entering business for himself. He re-entered the railroad service in 1912 on the Mechanical staff of the New York Central Lines at New York and Chicago, holding this position until 1915. He was reappointed Mechanical Engineer of the Michigan Central on April 1, 1913, and held this position until his death.

Alexander Beal Brown, General Representative, Air Brake Department, Canadian Westinghouse Company, Limited, died at his home in Montreal, Quebec, on Wednesday, June 8, 1927, after an illness of several months' duration.

Mr. Brown was born on June 6, 1873, in Scranton, Pa., where his father was Assistant Superintendent of Motive Power with the Delaware, Lackawanna & Western Railroad. After he completed his education in the Public Schools of his home city in 1887, he entered the employ of the Delaware, Lackawanna and Western Railroad as an apprentice in the machine shop, and, upon finishing his apprenticeship, he was transferred to the Air Brake Inspection department and made assistant to the Air Brake Inspection foreman. He remained in this position until in 1897 he was offered an appointment by the Westinghouse Air Brake Company as an assistant in the Westinghouse Air Brake Instruction car, which he promptly accepted. He was subsequently given the position of inspector with the Air Brake Company at Buffalo, where he remained until 1903, when he was transferred to Hamilton, Canada, to act in a similar capacity with the Canadian Westinghouse Company, making his headquarters in Montreal, Quebec. He afterwards was appointed General Representative of the Air Brake department of that company, which position he held at the time of his death.

He took ill about two months ago, but while his recovery was expected, the end came quite suddenly. He died at his home in Montreal, survived by his widow and three sons.

Arthur W. Trenholm, former vice-president of the Chicago, St. Paul, Minneapolis & Omaha Railway, who retired from service in 1925, died on May 13 at his home at St. Paul, Minn. Mr. Trenholm entered railway service in 1869 as a water boy on the Intercolonial, now a part of the Canadian National Railways. In 1873 he worked on this railroad as a laborer, then becoming an operator and relief agent on the Grand Trunk accounting department as a local agent. His connection with the Chicago, St. Paul, Minneapolis & Omaha Railway began in 1880, when he was appointed as a traveling auditor, remaining in this capacity until 1893, when he was transferred to the operating department and advanced to division superintendent. In 1900 he was promoted to general superintendent and from 1903 to 1918, he was general manager; he also served as vice-president during the period of government control. In 1920 he became vice-president of the Chicago, St. Paul, Minneapolis & Omaha Railway, a position he held until his retirement in November, 1925, after 45 years of service with the Chicago, St. Paul, Minneapolis & Omaha Railway.

Henry E. Huntington, formerly chairman of the board of the Chesapeake & Ohio Railway and the Hocking Valley Railway, died on May 23, at Philadelphia, Pa. Mr. Huntington superintended the construction of the Huntington lines between New Orleans and Louisville, giving special attention to the construction of the Chesapeake, Ohio & Southwestern; he continued in the capacity until 1884, he was appointed superintendent of the Kentucky Central, then being operated by the Chesapeake & Ohio Railway. In 1885 he was appointed receiver of the Kentucky Central, and a year later, when the property was sold, he was appointed vice-president and general manager, holding these positions until the road was sold to the Louisville & Nashville Railroad, when he was chosen vice-president and general manager of the Elizabethtown, Lexington & Big Sandy and the Ohio Valley. He continued in charge of these roads until they were sold, when he went to California. During his connection with the Kentucky Central he was also superintendent of the construction of the Maysville & Big Sandy. He had charge of the construction company which built the lines through Covington, Ky., and Cincinnati, Ohio, including the Ohio river bridge, he served as first assistant to the president of the Southern Pacific, representing the president at San Francisco. In 1900 he was second vice-president and from June, 1900, until June, 1904, first vice-president of the same company. He was also chairman of the board and a director of the Chesapeake & Ohio Railway, the Chesapeake and Ohio Northern and the Hocking Valley Railway and a director of the Minneapolis & St. Louis Railroad and the

Southern Pacific. Mr. Huntington retired from active railroad service in 1922.

C. G. Juneau, master car builder of the Chicago, Milwaukee & St. Paul Railway, died on May 26. Mr. Juneau was born in 1874, at Milwaukee, Wisconsin. He entered railway service as a blacksmith apprentice in the car and locomotive departments of the Chicago, Milwaukee & St. Paul, and completed his apprenticeship in 1899. Mr. Juneau was later appointed assistant foreman of the blacksmith shop, where he remained until 1918, when he was further advanced to general foreman of the blacksmith department for the entire system. He was promoted to general superintendent of the freight car department in 1918 and in 1920 he was again promoted to take charge of the Milwaukee terminal and shop district. Mr. Juneau was appointed acting master car builder, with headquarters at Milwaukee, Wisconsin, on June 1, 1920, and on August 1, 1920, he was appointed master car builder, a position he held continuously until the time of his death.

George C. Murray, formerly president of the Keyoke Railway Equipment Company, died on May 22. Mr. Murray became connected with the Simplex Railway Appliance Company in 1902, and was engaged by the American Steel Foundries, when the latter company absorbed the Simplex Railway Appliance Company in 1905. Mr. Murray obtained patents on the Murray draft gear and the Murray Keyoke and at this time formed and became president of the Keyoke Railway Equipment Company. He remained president of this company until about two years ago, when he retired on account of ill health.

Frederick M. Waterman, treasurer of the United States Steel Corporation, died at his home in Mahwah, New Jersey, on May 21. He was born at Wheaton, Ill., on January 20, 1872. Mr. Waterman was educated in the public schools at Westside, Iowa, and Iowa Business College. He entered the service of the Merchants Loan & Trust Company Bank, Chicago, Ill., where he remained until 1902, when he went with the United States Steel Corporation as cashier. In 1919, he was appointed assistant treasurer of the corporation and since 1922 has served as treasurer.

P. W. Kromer, district manager of the Air Reduction Sales Company, at Buffalo, New York, died on May 21, following an illness of five weeks. Mr. Kromer had been identified with the Oxyacetylene industry for nearly 20 years, of which 11 years were with the Air Reduction Sales Company, before his connection with the Air Reduction Sales Company in 1916. He was the local manager of the Niagara Oxygen Company.

New Publications

Books, Bulletins, Catalogues, etc.

Railway Fuel.—By Eugene McAuliffe, President, Union Pacific Coal Company. Pub. Simmons Boardman Publishing Company, 30 Church Street, New York City, 468 pages, illustrated.

A study of the fuel situation in relation to the operating costs and earnings of railroads. Production, purchase, transportation, and use are discussed and statistics presented. Coal and oil are both considered. The author endeavors to picture the difficulties that beset the coal industry, to give ideas of conditions, and to suggest remedies.

Tool Control.—By Anker L. Christensen. Pub. Ronald Press Company, New York, 134 pages, illustrated. Price $3.50. This book includes chapters on Procurement, Storage, Issue, Repairs and Cost. The author presents a system of tool control which is elastic enough to cover the requirement of both large and small plants efficiently. The methods given are based on the practice use by the author at the Worthington Pump and Machinery Corporation plant at Harrison, New Jersey.

Shop Hints on Locomotive Valve Setting.—By Jack Britton. Second edition. Pub. Simmons Boardman Publishing Company, 30 Church Street, New York City. 350 pages, illustrated. Price $3.00.

This book explains the theory of the locomotie valve gears in use, describes the details of their construction, and tells how to set them. The author is a practical valve setter, and the book is planned for use in erecting and repair shops.

Non-Technical Chats on Iron and Steel.—By La Verne W. Spring. Pub. Frederick A. Stokes Company, New York. 465 pp., illustrated. Price $4.00.

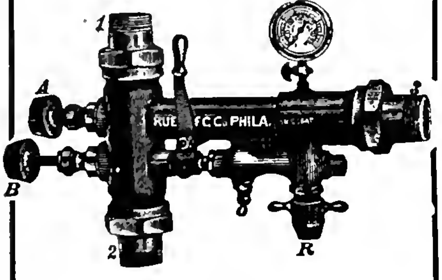
A popular, readable account of the iron industry, describing the metallurgical and mechanical processes of the blast furnace, steel works, foundry, and rolling mill, and accompanying the text by numerous well-selected photographs. This edition has been revised and enlarged to cover recent changes.

Diesel Engines.—By Arthur H. Goldingham, published by Spon & Chamberlin, 120 Liberty Street, New York City, 255 pages, illustrated. Price $7.50.

This being the third edition of this book the author has brought it up to date. Such wonderful progress has been made in the design and the construction of Diesel engines.

This edition should prove valuable to the student, draftsman, the consulting engineer or others who are interested in Diesel engines for use either ashore or afloat.

Bulk Storage Tanks.—The Graver Corporation, East Chicago, Ill., has just issued a 48 page catalog, illustrating and describing its extensive line of steel tanks. The catalog contains drawings of a number of bulk station lay out, a list of standard tank sizes with specifications and data in regard to storage plant fittings and structural tank supports, also with information with regard to the care of tanks as to their unloading and erecting. Copies of the catalog may be obtained on application to the Graver Corporation.



Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

Vol. XL 136 Liberty Street, New York, July, 1927 No. 7

New 4-8-4 Type Locomotives for the Canadian National

Silicon Steel Boilers Carry 250 Lb. Steam Pressure

The Canadian National Railway has ordered 40 locomotives of the 4-8-4 type, 20 from the Montreal Locomotive Works and 20 from Canadian Locomotive Company: An additional 12 locomotives of this same type are being built by the American Locomotive Company, for use on the Grand Trunk Western Railway.

The 4-8-4 locomotives are the first on this road to be equipped with 4-wheel trailing trucks, and has been designated the Northern type by the railroad. They were designed for either passenger or fast freight service. It is intended to use them on extended runs over two or more regular divisions. The first of the 20 ordered from the Canadian Locomotive Company was turned out the first week in June and was exhibited at Montreal during the convention of the Mechanical Division of the American Railway Association. These locomotives will operate on curves up to a maximum of 18 degrees.

The boiler is of the straight top type with radially stayed firebox, and carries 250 lb. pressure. In order to save weight the shell courses have been made of high tensile silicon steel, developed by the Carnegie Steel Company, with tensile strength from 70,000 to 83,000 lb., and minimum yield points of 38,000 lb. Steel staybolts are used throughout and the flexible bolts are of the F. B. C. welded telltale type. Security arch brick are carried on three 3-in. arch tubes and the two syphons in the firebox. None of the tubes or flues are welded to the back tube sheet. The boiler pressure carried, and the high tensile shell steel used in the boiler construction are of special interest. Reports implied some mystery in the manufacture of this steel and that special furnaces were necessary, but there is no mystery involved. It can be made by the usual basic open-hearth method, the silicon being added while the steel is being tapped. The usual additional precautions taken in the manufacture and inspection of boiler quality steel were observed in making the plates for the Canadian National Railway locomotives. As the minimum tensile strength specified for these plates was 10,000 lb. less than the standard grade of silicon steel, slightly lower carbon and silicon limits were used, giving the following average results from 350 tests: yield point, 46,146 lb.; tensile strength, 76,811 lb.; elongation, 25.2%; reduction in area, 47.1%. This permitted the construction of the boiler barrel for 250 lb. pressure with no added weight, compared with a similar boiler for 200 lb. pressure, with carbon steel plates.

New 4-8-4 Type Locomotive of the Canadian National Railways

The cab is a short, vestibule type, all steel, and wood lined. The turrets are located ahead of the cab, the left hand one being supplied with superheated steam by a 3-in. pipe leading from a connection on the superheater header, and the right hand one with saturated steam from a direct connection to the boiler. The superheater steam is supplied to air pump, feed water heat pump, stoker and headlight generator, while saturated steam is supplied to the steam heat line, inspirator, lubricator and other small auxiliaries. The Canadian National Railway standard 4-chime type whistle is located on the left hand side of the smokebox, near the stack with a 1-in. connection from the superheated steam line from the header, and is operated by wire cable carried through the handrail on the left hand side. The locomotive blow-off valves are located on the right side of the firebox, and can be operated in unison from the cab. Both blow-off cocks are connected to the sludge remover. One has an internal pipe connection along the bottom of the barrel, extending to within 2 ft. of the front tube sheet, and the other has a pipe connection across the throat, with opening opposite the side water legs. The side checks carry the feed water through troughs on the inside of the barrel down near the bottom of the tubes, so as to prevent deposits gathering on top of the tubes. The front end is fitted with Canadian National Standard barrel netting, and the exhaust tip. The smokebox front is of pressed steel, with a cast iron door. A Barco blower connection is applied on the left side of the smokebox.

The main frames are half nickel and half vanadium steel; the cradle castings are of Commonwealth type. Shoes and wedges are of cast iron. The cylinders are of cast iron, and both cylinders and valve chests are fitted with Hunt-Spiller bushings. Baker valve gear is applied. Maximum valve travel in forward motion is 9 in., and the valve setting is such that lap is 1 5/16 in., and exhaust clearance 3/16 in. The main driving journals are 12 x 13 in., and all others 10 x 13 in.

The locomotives are equipped with main driving boxes of the floating bushing bearing type. This design of box, developed on the Canadian National Railway, has been applied to the main drivers of a number of locomotives in both freight and passenger service, and the results secured have been so satisfactory that the same type is being applied to all of the 4-8-4 locomotives now being built. The box is made of cast steel, in two sections parted horizontally and held together by 4 fitted bolts. These are of high tensile steel. A high grade iron bushing is keyed into the cast steel box, and the brass floating bushing revolves between the journal and the iron bushing. The bushings are both made in two pieces, so that they may be removed if necessary. A ½ in. steel plate on the inside face of the box holds the bushings in place. The box is lubricated by ordinary driving journal compound, grease being supplied to the bearing from pockets, two at the top and two at the bottom of the box. The grease is carried from the pockets through holes and grooves in the bushing to the inner brass bearing. The brass bearing contains a large number of holes countersunk on the outside and full of grease. The grease from the two top pockets feeds the bearing when softened up, but on the two bottom pockets a plunger is applied, with a coil spring which will put some pressure on the grease and help to feed it to the bearing. The grease pockets open on the inside face of the box, and are each equipped with a plug; the plugs, when screwed in, being locked in pairs by a rod passing through them. It is stated that these boxes have run large mileages on one packing of grease, and the cost of lubrication is very low. Two eyebolts are screwed into the top half of the box, lifting off, and tapped holes are provided in the inside face of the floating bushing, to facilitate removal. This design of main driving box has eliminated pounding, and has reduced the amount of maintenance required on rods. It provides a very much larger continuous hub area than the conventional design. The big end of the main rod and the intermediate side rod connection are equipped with floating bushings bearing of Canadian National Railway design. The cylinders and valves are lubricated by a Nathan mechanical lubricator. The auxiliaries are lubricated by a three-feed Detroit hydrostatic lubricator in the cab.

Another feature of these locomotives is the engine truck, a 4-wheel outside bearing engine truck with floating bushing bearings, grease lubricated, and with steel-tired wheels 34¼ in. in diameter with cast steel spoked centers. The truck frame, with bolster and lateral resistance device is a Commonwealth design. The boxes are vanadium cast steel, with high grade hard iron bushings pressed in, and a 7 x 10 in. hard bronze bearing revolving between the journal and the iron bushing. A removable collar on the end of the axle holds the bearing in place and at the same time by its lateral movement pumps the grease into the bearing. The cover contains a removable plug for applying grease. A bronze liner is applied on the inside face of the box, and between this bronze liner and the inner end of the floating bushing a felt ring in a brass container is applied to hold the grease in the box. The spring arrangement on this truck is novel, there being three semi-elliptic springs on each side, the center one acting as an equalizer, while the other two are each under a box with the spring seat cast integral with the box. A 4-wheel truck, with inside journals and floating bushing bearings, similar to the main driving wheel boxes, is in service on the Canadian National Railway and has been giving good results.

The trailing truck is of the Commonwealth 4-wheel design, with steel tired wheels 34¼ in. diam. on the front axle and 48 in. diam. on the rear axle. The journals are 7 x 12 and 9 x 14 in. respectively, and the boxes are of the floating bushing type. The front axles floats with a total lateral of 1¼ in., while on the rear axle the total lateral is ⅜ in. Franklin boosters are being applied to 10 of the locomotives ordered from Canadian Locomotive Company, but all trailing trucks are being arranged so that boosters may be applied later. The design of boxes and bearings is very similar to those on the engine truck, with the exception of the grease retaining rings, which are of bronze instead of felt. With this design of floating bushing engine truck, trailing truck and driving box bearings, where the width between the jaws is limited, the iron bushing can be replaced by a hard steel bushing, which allows a thinner section to be used.

The tender frame is of Commonwealth design, and the tank is the Vanderbilt type. Tender trucks are Commonwealth 6-wheel, with 6 x 11 in. journals, 34¼ in. steel tired wheels with semi-steel centers, McCord journal boxes.

Another feature of these locomotives is the use of a common exhaust pipe, on the left side, for the air pump, feed-water heater pump and stoker. It is carried forward and tees into the exhaust steam pipe leading from the exhaust passage in the cylinder saddle to the feed water heater located on top of the smoke box. On booster equipped locomotives, the exhaust from the booster is carried along the right side of the locomotive, and tees into the exhaust pipe on the right side leading from the cylinder to the feed water heater, and a special Crane check valve is applied at the booster exhaust line.

All of the locomotives are being equipped with Duplex type D-1 stoker, Elesco K-39 feed-water heater with the C. F. pumps; American Multiple throttles; Precision reverse gear; and the thermic syphons, two of the latter in the firebox and one in the combustion chamber. The locomotives being built by Montreal Locomotive Works are being equipped with Shoemaker firedoors; also lateral motion device on front drivers; and Miner draft gear. Those being built by Canadian Locomotive Company are being equipped with Franklin firedoors; Franklin power grate shakers; cast iron grates; Franklin lateral motion device on front drivers; and Cardwell draft gear. Other equipment, common to all the locomotives, includes Huron arch tube and washout plugs; Consolidated safety valves; Hancock inspirator on right hand side; Hancock side checks; improved type Ashcroft cut-off control gauge; air operated cylinder cocks; Canadian National Railway standard cast steel water column and mountings. Ashcroft steam gauge; nickel steel main axles, main crank pins, side and main rods, carbon steel springs, except in engine truck, which are of silicon manganese steel; Laird cross head with removable shoe, Canadian National standard steel pilot and cast steel bumper beam; World Leslie steam heat reducing valve and tank valves.

The principal dimensions and weights are given in the accompanying table.

Principal Dimensions and Weights of Canadian National 4-8-4 Type Locomotive

Type of locomotive	4-8-4	
Service	Pass. and frt.	
Cylinders, diameter and stroke	25½ in. by 30 in.	
Valve gear, type	Baker	
Valves, piston type, size	14 in.	
Maximum travel	9 in.	
Lap	1 5/16 in.	
Exhaust clearance	3/16 in.	
Lead	5/16 in.	
Weights in working order:	With booster	Without booster
On drivers	232,000 lb.	230,000 lb.
On front truck	65,000 lb.	65,000 lb.
On trailing truck	91,000 lb.	83,000 lb.
Total engine	388,000 lb.	378,000 lb.
Tender	260,000 lb.	260,000 lb.
Wheel bases:		
Driving	19 ft. 6 in.	
Total engine	43 ft. 10 in.	
Total engine and tender	82 ft. 0 in.	
Wheels, diameter outside tires:		
Driving	73 in.	
Front truck	34¼ in.	
Trailing truck	34½ in., front; 48 in., rear	
Journals, diameter and length:		
Driving, main	12 in. by 13 in.	
Driving, others	10 in. by 13 in.	
Engine truck	7 in. by 10 in.	
Trailing truck	7 in. by 12 in., front 9 in. by 14 in., rear	
Boiler:		
Type	Straight top	
Steam pressure	250 lb.	
Fuel, kind	Bit. coal	
Diameter, first ring, inside	80⅞ in.	
Diameter, largest course, outside	90 in.	
Firebox, length and width	126⅛ in. by 96¼ in.	
Arch tubes, number and diameter	3—3 in.; 2 syphons	
Combustion chamber length	48½ in.	
Tubes, number and diameter	27—2¼ in. 15—3½ in.	
Flues, number and diameter	162—3½ in.	
Length over tube sheets	21 ft. 6 in.	
Grate area	84.4 sq. ft.	
Heating surfaces:		
Firebox and comb. chamber	315 sq. ft.	
Arch tubes and syphons	117 sq. ft.	
Tubes and flues	3,814 sq. ft.	
Total evaporative	4,256 sq. ft.	
Superheating	1,700 sq. ft.	
Comb. evaporative and superheating	5,956 sq. ft.	
Tender:		
Style	Vanderbilt	
Water capacity	11,300 Imp. gal.	
Fuel capacity	20 tons	
Rated tractive force, engine	56,800 lb.	
Rated tractive force, engine and booster	67,700 lb.	

Great Northern Electric Locomotives

General Description of Rotating Apparatus and Operating Features

By E. R. MARTIN, Motor Engineer, Westinghouse Electric & Manufacturing Company

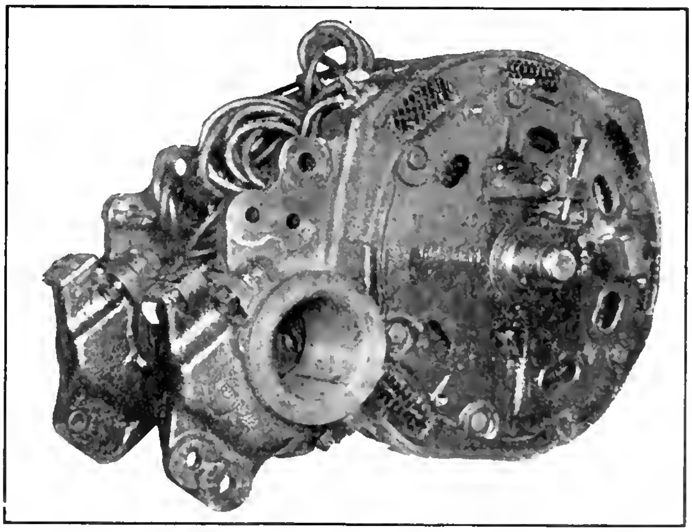
The change in the Great Northern Railways Cascade tunnel operation from three-phase, 6,600 volts to 11,000 volts, single-phase, has many points of interest to those in touch with railroad electrification. Data concerning the motor-generator locomotives (two cabs) is given in the following table:

Length overall	94 ft. 4 in.
Total weight	357.5 tons
Weight on 8 driving axles	275 tons
One hour rating	4,330 hp.
Continuous rating	3,660 hp.
Speed at one hour rating (F.F.)	14.4 mph.
Speed at continuous rating (F.F.)	15.5 mph.

The locomotive cabs, Fig. 1, are each equipped with a 1,500-kw. motor-generator set, three blower motors, one compressor, and four traction motors. Power is supplied through a 2,000 kv-a. locomotive type transformer, which is air-cooled by forced ventilation. It steps the voltage down from 10,500 to 1,240 for the synchronous motor. The insulated secondary has two taps, 50 per cent, the former being grounded through a detector.

Motor Equipment

The synchronous motor is completely wound with a lap winding, some of the coils being used to provide a two-phase voltage to combine with half the voltage of the transformer to form a three-phase supply for driving the blower motors for the transformer and main motors. The winding is specially designed for low reactance to increase the pull-out torque, which feature is also considered in designing the revolving field for high excitation. The field is 4-pole, wound for 125 volts, d-c., and has a field discharge resistance for use in stopping and starting. The rotor also carries a heavy squirrel-cage winding for starting and for damping.



Traction Motors for Great Northern Motor-Generator Locomotive

The generator is a compensated 600 volts d-c. machine, slightly differentially compounded, separately excited through a shunt winding from a 125-volt exciter. It has eight poles and is well cross-connected for balancing the lap winding.

The motor and generator are bolted together with a fan housing between them. Feet along each side of each machine are held down by bolts. The rotor is carried by two bracket bearings. The fan draws air through the sides of the cab and into the bearing end of each machine and exhausts it through the roof and floor of the cab. The end housings also carry the exciter frames without additional bearings. A 75-kw., 125-volt, 6-pole, flat compounded exciter furnishes current for the synchronous motor field, generator shunt field, regeneration exciter field, compressor motor, lights, control, and battery charging.

The regeneration exciter is a 25-kw., 10-volt, 8-pole machine furnishing current for the traction motors for operation during separate excitation, motoring or regenerating.

The traction motors are 6-pole, 600-volt, 750-ampere, 540-hp. axle mounted, running at 460-rpm., full field. (See Fig. 2.) They are forced-ventilated, on the horizontal system, the air entering above the commutator and blowing between the field coils, through the air gap, through the round holes in the armature core, and out the rear end through the frame and housing. The armatures are lap wound and well equalized. Both interpoles and main poles have coils edge wound with heavy strap. The motors are flexibly geared at each end. The gearing ratio 18 to 91, 2 D. P., with 5¼ inch face.

Two Unit Motor Generator Locomotive of the Great Northern Railway

The compressor motor, rated at 35 hp., 125 volts, drives a 150-ft. compressor up to 135 pounds per square inch. The blowers are driven by 660-volt, 3-phase, 4-pole, 10-hp. induction motors, one being used for the ventilation of the transformer and regeneration exciter, and one for each pair of driving motors.

Starting

The synchronous motor is started by connecting the 125-volt lead storage battery to the main generator through resistance. After this is cut out and the field weakened sufficiently to obtain about one-third speed, the motor is switched to the 75 per cent tap of the transformer and the battery disconnected. The motor comes up to speed as an induction motor and a weak speed is applied at about 80 per cent speed to force it into synchronism in the proper phase relation. A reactor is then automatically connected across the 25 per cent section of the transformer, the 75 per cent tap opened, and the reactor short-circuited, thus applying normal voltage with very little disturbance. The synchronous motor runs light at a field excitation that will produce a somewhat leading power factor.

Locomotive Performance

The locomotive is started by moving the main controller handle to apply higher excitation to the synchronous motor field and give a low excitation to the generator. The main motors are all connected in parallel and start under low voltage without external resistance or changing connections. Thus, with the proper current, they will exert their full tractive effort at a low power input at a lower power demand from the line. As the controller handle is advanced for higher speeds, the main generator field is strengthened by cutting out shunt field resistance until full voltage is reached from which point the motors run on their series characteristic. If a higher speed is desired, it is only necessary to balance the regeneration exciter voltage against the series field drop by varying the regeneration controller (or separate excitation controller) with the armature circuit of the regeneration exciter connected. When this has been done, as shown by a zero reading on a voltmeter, a push button is operated, throwing in the stabilizing resistance, and separate excitation exists with a one-to-one ratio of field and armature currents on the main motors. Stepping back on the regeneration controller will weaken the main motor fields and obtain higher speeds. Advancing the controller will strengthen the fields and reduce speed or cause the locomotive to regenerate. If the field of the main generator is reduced (when it is motoring) by returning the main controller handle, regeneration is increased and may be carried down to about four mph. at full rated retarding effort, or in other words, the train can be practically stopped by degeneration.

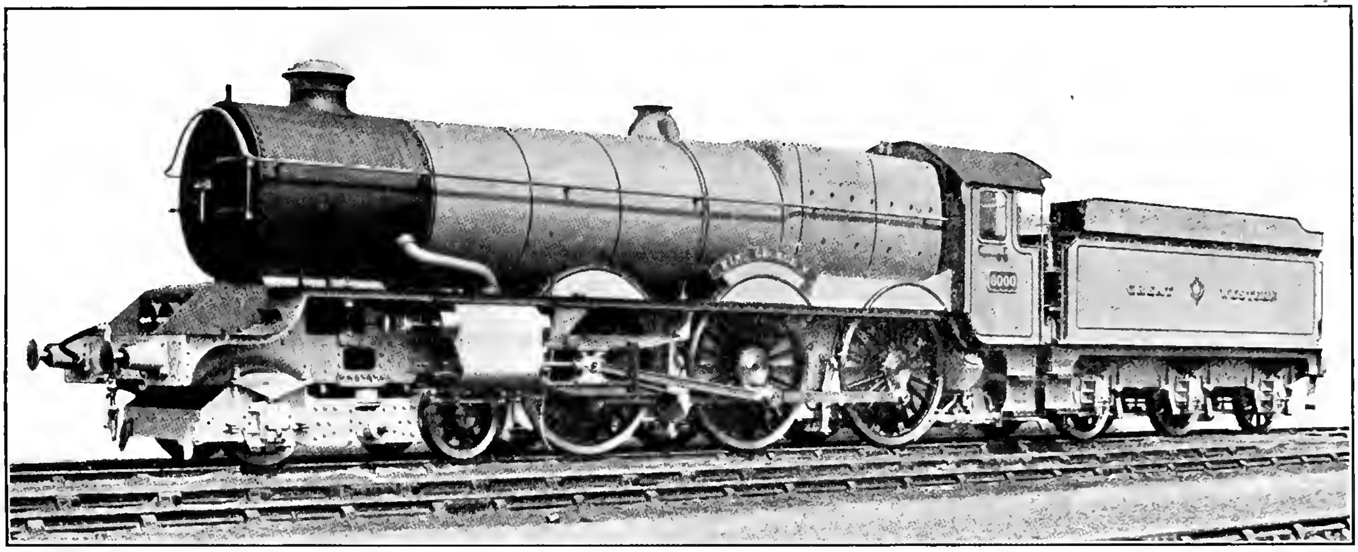
This gives a control system of great flexibility and enables the engineman to operate the locomotive at constant horsepower output under a wide variety of conditions. In case the sychronous motor is overloaded, a current relay applied super-excitation and reduces the voltage of the generator as a warning to the engineman. If the set is pulled out of step, it drops its load and automatically pulls into synchronism ready for reloading.

New Four-Cylinder 4-6-0 Type Locomotive

Most Powerful Locomotive for Passenger Service in Great Britain

The Great Western Railway Company of England are constructing at their Swindon Works twenty express passenger locomotives of the four-cylinder, 4-6-0 type to be known as the "King" class, named after the Kings of England, the first completed engine being appropriately named after the reigning monarch.

The new locomotives are being built to designs by C. B. Collett, O. B. E., chief mechanical engineer of the railway, and are the most powerful express passenger locomotives in Great Britain, their tractive effort 40,300 lb. at 85 per cent of the boiler pressure, being considerably higher than that of any other in that country.



Four Cylinder 4-6-0 Type Locomotive of the Great Western Railway of England

It is interesting to note that the "King George V" is to be sent to America as representing the latest and largest development in British locomotive practive. It will be shown in connection with the Centenary Exhibition of the Baltimore & Ohio Railroad at Baltimore, Maryland, September 24th to October 8th. It will be accompanied by the reconstructed "North Star" which was exhibited at the British Empire Exhibition at Wembley.

Distribution of the adhesion weight is effected by an equalizing arrangement on the six coupled wheels, the total being 151,200 lbs. whilst the weight on the truck is 48,160 lbs. The total weight of the engine in working order, without the tender being 199,360 lbs. The tender is of the standard Great Western Railway six-wheeled design, equipped with water pick-up apparatus. It weighs when full 104,600 lbs. and has a capacity of over 6½ tons of fuel and 4,000 gallons of water. The weight of the engine and tender in working order is 303,960 lbs.

New features are presented in the four-wheeled trucks, which is spring controlled, and of unique design. It has outside bearings on the leading axle, and inside bearing on the trailing axle, this arrangement being necessary in order to obtain clearance between the truck and the cylinders.

The four cylinders are not set in a line across the engine, but the inside pair are set well forward in the frames, and drive on to the leading coupled axle, and the outside pair drive on to the middle coupled wheels.

Steam is supplied to the inside cylinders by piston valves operated direct from the walschaert gear placed between the frames, the valves for the outside cylinders being operated by rocking levers from the inside gear. The inside connecting rods have forked big ends fitted with gib and cotter, but the outside rods have solid bushed ends. The boiler carries a working pressure of 250 lbs. per square inch, and is built with conical barrel and Belpaire firebox, without a dome. The steam is taken from an open pipe at the highest point over the firebox and the safety valve is mounted on the barrel.

In constructing the inside firebox, copper stayed entirely by direct steel, is used with copper stays to the outside casing; and the standard Swindon type superheater fitted. The boiler is also fitted with top feed, the water being fed through pipes in the safety-valve casting. Equalized vacuum braking is operated on all the coupled wheels. The cab is spacious, well protected by an extended roof and side windows, and fitted with audible signal gear for use over section equipped for automatic train control.

The engine is finished in same style as that adopted for other Great Western Railway express passenger engines. Features which contribute to a handsome appearance are the chimney-top of copper, safety-valve cover and cab and splasher beadings of brass, polished handrails, etc.

Some of the principal dimensions of the locomotives are given in the following table:

Cylinders (4) diameter	16¼ in.
Cylinders piston stroke	28 in.
Wheels, bogie, diameter	3 ft. 0 in.
Wheels, coupled, diameter	6 ft. 6 in.
Wheelbase, bogie	7 ft. 8 in.
Wheelbase, coupled,	16 ft. 3 in.
Wheelbase, total engine	29 ft. 5 in.
Boiler pressure	250 lb. per sq. in.
Boiler, length of barrel	16 ft. 0 in.
Boiler, diameter outside	6 ft. 0 in. and 5 ft. 6¼ in.
Firebox, length outside	11 ft. 6 in.
Boiler, center from rail	8 ft. 11¼ in.
Heating surface, total	2,514 sq. ft.
Grate area	34.3 sq. ft.
Tractive effort, at 85% boiler pressure	40,300 lb.
Weight (engine only) in working order	89 tons

Mechanical Division Meeting of the A. R. A.

Papers and Reports Presented at the Annual June Meeting

The abstract from the commitee report on locomotive design and construction, the paper by Dr. W. F. M. Goss on the Next Step in the Development of Locomotive Drafting and also the paper by Victor N. Willoughby on Passenger and Freight Car Design presented at the annual meeting of the Mechanical Division of the American Railway Association last month and published on this and the following pages were excellent contributions to the work of the organization.

The report of the Committee on Locomotive Design and Construction was devoted to the standardization of driving, engine truck and trailer axles of steam locomotives and to a study of frame attachments for boilers. The committee also discussed the relative merits of the three- and two-cylinder arrangements, and the possibilities of high boiler pressures.

Dr. Goss is a recognized authority on the drafting of locomotives, and has conducted much research for the purpose of securing reliable information which would aid in a logical design of an efficient drafting apparatus.

Dr. Goss's present preference to work on an application of an exhaust-fan, directly connected with a steam turbine energized by the exhaust steam from the locomotive cylinders, is of particular interest because exhaust fans, as they have been tried on locomotives in the past have always failed. He has approached the subject from the standpoint of scientific inquiry which has freed him, as he says, from many conservative restraints that have been set up by tradition.

Mr. Willoughby is general mechanical engineer of the American Car and Foundry Company and in his paper discusses the improved designs of cars that must be provided to take care of the additional traffic the transportation facilities are being called on to handle.

Developments in Locomotive Drafting

By W. F. M. Goss

It will already have been surmised that my next step involves the use of a suitably designed and suitably driven exhaust-fan. I have approached my subject with deliberation because I appreciate the reluctance with which locomotive men contemplate such a process. They know it to be a historic fact, that exhaust-fans have been tried on locomotives at various times and in many places, and that they have never been continued in service. It has become a tradition with railroad men that exhaust-fans in locomotive service have always failed. The reasons for their failure, whether the conception was at fault or the design poor, or the materials badly chosen, are rarely sought, and tradition holds its sway.

If, now, instead of relying upon the tenets of traditions, we approach this subject from the standpoint of scientific inquiry, we are at once freed from many conservative restraints. The problem is one which I have carefully studied. I have been fortunate in having had the co-operation of able interests in the development of designs, in the conduct of laboratory experiments, and in tests of an experimentally equipped locomotive on the road; all with the result that much reliable information concerning the possibilities of the exhaust-fan in locomotive service is now available. In fact, speaking from a scientific point of view, mechanical draft in locomotive service is today better understood than was the present front-end with its open exhaust-jet before this Association had undertaken its development, thirty years ago.

Darius Green attempting flight by chance, failed in his purpose, and established a tradition that flight by man was impracticable; the Wright Brothers, guided by scientific procedures, shattered that tradition and attained successful flight. The art of producing draft in locomotive service has now reached a condition of scientific stability. The theory underlying design of exhaust-fans for producing draft, and of steam turbines for driving them is now well understood; our range of choice in the selection of materials from which to construct such equipment has, in recent years, been extended, and men of skill are ready to proceed with the details of design. We never really achieve until we are able to step beyond the limits of present day accomplishments. It is time for the next step. Shall we take it?

The Turbo-Exhauster

A decision to proceed with the installation of mechanical draft in locomotive service at once opens the way for many different arrangements of details. I have preferred to work on an application of an exhaust-fan, directly connected with a steam turbine energized by the exhaust steam from the locomotive cylinders. The combination of turbine and fan, hereinafter referred to as the "turbo-exhauster," is a self-contained unit having a single shaft carrying a steam-turbine wheel at one end, and an exhaust-fan wheel at the other. The locomotive exhausts directly into the steam-supply header of the turbine, from which it passes through nozzles of appropriate size to the turbine wheel. The turbine takes all the exhaust from the locomotive cylinders, not a part of it. The nozzles of the turbine are the exhaust-tips of the new arrangement. The steam having done its work on the turbine wheel is discharged into a casing which conveys it along the shaft of the turbo-exhauster to a point close to the back of the fan-wheel, where it flows in a steady stream into the front-end.

The course of the exhaust from the turbine wheel to the front-end is such that it maintains an atmosphere of exhaust steam about the journals and bearing of the turbo-exhauster and at the back of the exhaust-fan wheel. The pressure of this steam is merely the pressure of the front-end, and its temperature can never be higher than the temperature of steam at or below atmospheric pressure. This arrangement entirely disposes of any trouble which might otherwise be anticipated in maintaining journals and journal boxes within the front-end of a locomotive.

The turbo-exhauster has no valves or governors or other elements of control. All steam that the locomotive exhausts goes to the turbine wheel and the energy that it imparts to the turbine wheel is absorbed by the exhaust-fan wheel, so that the draft action induced by the turbo-exhauster responds to the volume of steam exhausted by the locomotive just as does the draft action in the presence of the open exhaust-jet now in use.

The exhaust of air pumps and of other steam auxiliaries is piped into the steam-header of the turbine, where it goes the same course as the exhaust from the locomotive cylinders. Experiments have shown that the exhaust from the air pump alone is quite sufficient to keep the turbo-exhauster in motion when the throttle of the locomotive is closed, so that on the road the turbo-exhauster never stops, though its speed may vary between very wide limits.

Quite independent of the steam-supply casing of the turbine is a small high-pressure steam header covering a nest of high-pressure nozzles arranged to act upon the turbine wheel. The usual blower pipe connects with this high-pressure header. In firing up, the round-house steam-hose is attached to blower pipe, steam is turned on, and the turbo-exhauster, operating as a high-pressure steam turbine in quietness and efficiency not otherwise obtained, begins its work. The blower may be used as needed, not only when the throttle is closed but also on the road, when the throttle is open, and there is need of a real draft booster. The fact that the blower nozzles are independent of the exhaust nozzles permits them to be effective when worked either independently or in combination with the others.

The turbo-exhauster as a whole is arranged in the front-end immediately ahead of the superheater. Its shaft is parallel but not necessarily in line with the center line of boiler. In its application to existing locomotives it will often be found practicable to put it into existing front-ends, but the preferred arrangement is one which provides a short extension front-end ring within which all parts of the turbo-exhauster may be permanently installed. The stack is ordinarily moved forward to the new ring and the old stack-base sealed by a man-hole cover, by the removal of which admission is given for inspection of superheater and related parts. When a full exposure of the front-end is necessary, the supplemental ring carrying with it all parts of the turbo-exhauster is easily and quickly removed.

The turbo-exhauster presents no difficulties either of design or application arising from scientific considerations. Its fundamental details have all been analyzed and tested. Assuming that the functions it performs are desirable functions, its scientific soundness should insure its ultimate introduction.

The Turbo-Exhauster as a Draft Producer

The efficiency of the turbo-exhauster as a producer of draft is the combined efficiency of the steam-turbine and the exhaust-fan. The steam-turbine is a device of comparatively high mechanical efficiency, but the conditions of service in the front-end of a locomotive are variable, and very high efficiency is not to be expected. In my initial study of the matter I assumed an efficiency of 60 per cent for the turbine. The exhaust-fan, with its cinder trap, is necessarily a fan of low efficiency, and I accepted for it an efficiency of 40 per cent. Under these estimates, the combined efficiency is .40×.60=.24; that is, the turbo-exhauster will return in useful draft effect substantially 25 per cent of the initial energy of the exhaust steam, which is to be compared with 8 per cent now obtained from the open exhaust-jet.

If we convert this increase in efficiency into reduction in back-pressure, by reference to a record of performance of the Mikado locomotive tested by Professor E. C. Schmidt, to which reference has already been made, the facts are as follows:

RESULTS OF TESTS—NORMAL LOCOMOTIVE

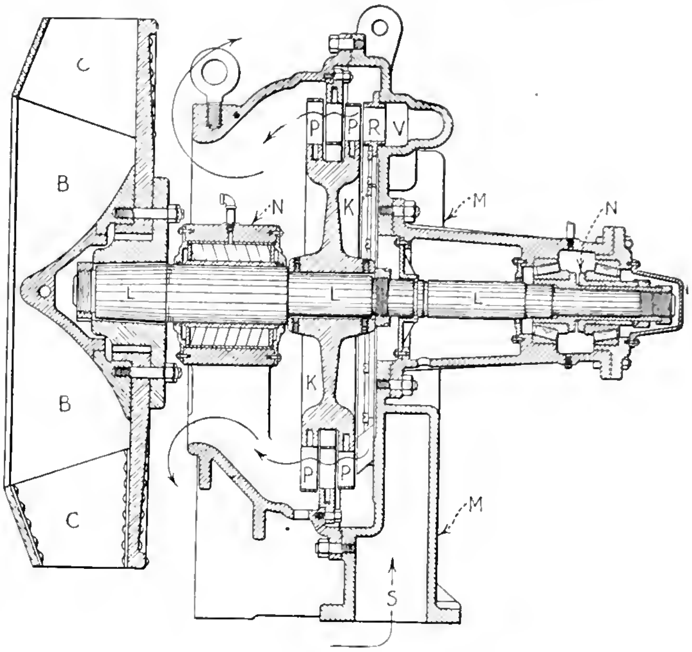
		Medium Power	Heavy Power
(a)	Pounds of coal per hour....	2,900.0	6,600.0
(b)	Pounds of steam per hour..	23,000.0	42,000.0
(c)	Pressure of exhaust.......	2.0	12.0
(d)	Draft, inches of water.....	2.0	7.0

RESULTS WHICH WOULD BE AVAILABLE THROUGH USE OF TURBO-EXHAUSTER

(e)	Pressure of exhaust.......	.85	3.4
(f)	Reduction in pressure exhaust, pounds	1.15	8.6
(g)	Reduction in pressure of exhaust, percentage of (Item c)	57.0	72.

These values representing the possible performance of the turbo-exhauster as a draft producer are based upon an assumed performance of the turbine and fan. They have been confirmed in general terms by the performance of experimental equipment in service on the road. It has been shown experimentally that the turbo-exhauster easily supplies all the draft needed, on a back-pressure which is less than half that now employed. Obviously there are great possibilities in this direction, which await the introduction of a more highly perfected design of turbo and fan.

Accepting for the present a reduction of 60 per cent in pressure of exhaust of our present day locomotive, it follows that the turbo-exhauster will save from five (5) to twelve (12) per cent of steam now used, the precise amount depending upon running conditions. Since, in locomotive service, economy in the use of steam can always be transformed into increase of power, it may be said that the turbo-exhauster, when applied to a modern locomotive, becomes a power booster to the extent of from 200 *to* 400 *horse-power*.



A Vertical Section of an Experimental Turbo-Exhauster

The Turbo-Exhauster as a Muffler

One effect of the higher efficiency of the turbo-exhauster as compared with the open exhaust-jet now used is a complete elimination of all noise of exhaust. Experience has shown that a two-stage turbine wheel completely silences the exhaust of cylinders and air pumps and the roar of the blower jet. Regarded merely as a muffler, the turbo-exhauster, unlike most mufflers, does not impede discharge, but actually brings about a reduction of pressure in the energizing stream.

The time has come when the designing engineer cannot be content with any device, however convenient or serviceable, the action of which results in unnecessary noise. The cost of noise in dollars and in human lives is large, and a modification in design which will permit a steam locomotive to approach the electric locomotive in quietness of operation is in itself worthy of attention.

The Turbo-Exhauster and Spark Discharges

The discharge of solids from locomotive stacks has thus far refused to be suppressed. It is not that the solids cannot be separated from the gases, but that when separated, they cannot be gotten out of the front end, which, when the locomotive is operating, is always below atmospheric pressure. There have been many attempts to provide a side-door for their orderly exit, but they would never use the door; they have always insisted upon passing out through the broad avenue by which everything else finds its exit from the front-end.

In this matter the introduction of the turbo-exhauster brings about a complete change. The solids entrained by the gases are collected in an intercepting ring-collector on the discharge side of the fan, where the fan pressure is maximum, and hence always above the pressure of the atmosphere. All solids thus collected are discharged by a separate pipe, preferably into the firebox though, if the operator prefers, there is nothing to prevent their being delivered to the ash-pan or upon the road-bed.

This apparently easy disposal of the solids is due entirely to the fact that they are collected in a zone which is always at a higher pressure than that of the atmosphere. All that needs to be done to get them out of mechanism is to provide an outlet through which they may pass.

It is evident that the turbo-exhauster, by returning to the fire-box the solids which now pass out of the stack, is to be credited with such gain in the efficiency and power of the locomotive as a whole as may accrue from such action. Under present conditions of stoker firing, the effect upon output of power is complex, and I have not attempted to analyze it, but its effect upon fuel consumption cannot, I think, be questioned. The tests of fuel in locomotive service to which I have already referred, show that with mine-run coal at medium power, 3 per cent, and at heavy power, 9 per cent, of the heating value of the fuel fire was discharged from the stack. There seems to be no doubt that a device which will return to the firebox the fuels thus discharged will recover these percentages of fuel.

Again the discharge of solids from the stack constitutes one of the serious objections to the presence in congested communities of the modern steam locomotive. The abatement of all such discharges, even if no use is made of their fuel value, represents a very potent advantage to be derived from the use of the turbo-exhauster.

Tests of the Turbo-Exhauster

Steps have been taken to advance the state of the art represented by the turbo-exhauster. The theory of the device has been re-examined, model forms of exhaust-fans and cinder traps have been made and elaborately tested, and a series of full-sized turbo-exhausters have been installed and tested on a locomotive in road service. This work of design and testing, most skillfully conducted, has disclosed:

1. A complete confirmation of results predicted based on theoretical examination and analysis; that is, the device has done in service what the underlying theory said it would do.

2. That its use facilitates the process of firing up a locomotive.

3. That it supplies the requisite draft to make the locomotive steam satisfactorily in ordinary service.

4. That the back-pressure required to maintain satisfactory draft conditions is not more than half that normally required.

5. That the exhaust from the air pump is sufficient to keep the fan turning when the throttle is closed.

6. That its use supplies the same element of balance between volume of steam delivered by the boiler, and force of draft controlling volume of steam produced, as is given by the open exhaust tip.

7. That in case of low steam-pressure on the road, the blower nozzle can be effectively used when the throttle is open, the blower supplementing the exhaust.

8. That the noise of the exhaust from the cylinders, from the air pump, and from the blower, is eliminated.

9. That objectionable cloud characteristics of the smoke discharge from the stack are diminished.

10. That the discharge of solids from the stack is reduced to an amount that is negligible.

It is but fair to add that the service tests developed two sources of difficulty, that the line of solution is in each case apparent but that the solution has not yet been worked out in service. The difficulties and the means by which it will be sought to overcome them are as follows:

(a) The fan wheel suffered severely from the abrasive action of the solids entrained by the gases it was required to handle. The first fan put in service failed after a few hundred locomotive miles; a later fan tested withstood service for five thousand locomotive miles. The service requires a fan-wheel which can be depended upon for at least 25,000 miles. It is proposed to secure such a wheel by progress along three different lines, thus:

1. By making the fan-wheel respond more nearly to smoother stream lines, and to improve the character of material from which the fan-wheel is made.

2. By making certain parts of the fan-wheel heavier, and

3. By reducing the work upon the fan-wheel by applying to the intake tube a series of inside spiral fins, so designed as to give the approaching gases, with their burden of entrained solids, a whirl in the direction of the fan-wheel's motion, in order that the blades of the fan-wheel will not alone be required to produce rotary motion in the gases and the entrained solids. As abrasive action diminishes rapidly with reductions in velocity of impact, even slight reductions in this velocity will serve greatly to prolong the life of the fan-wheel.

(b) The efficiency of the turbo diminished under service conditions as a result of the accumulation of oil from the exhaust on its blades. Such accumulation was found to require attention at intervals of approximately 2,000 locomotive miles.

It is obvious that the necessity for such attention would be entirely overcome if it should be found possible to introduce an oil separator in the exhaust-pipe connection, and there is a probability that such a solution can be had. In the event that it is not practicable to so separate the oil from the exhaust of the locomotive, it will be entirely practicable to inject into the turbine, at proper intervals, a solvent which can be depended upon to dissolve the encrustation.

The tests having been entered upon for a distinct purpose which did not necessarily involve the complete experimental development of the turbo-exhauster, were terminated, when the purpose for which they had been undertaken had been accomplished.

I present this statement of conclusions based on the known performance of the turbo-exhauster as a description of results now obtainable in locomotive service. The peculiarities of the mechanism of the turbo-exhauster are incidents, the important matter concerns the value of the possible results set forth. Do we want locomotives which will function in the manner herein described? If that question were to be answered definitely in the affirmative, there are many willing hands which would appear to serve in the production of such locomotives. Are you ready for the next step?

Passenger and Freight Car Design

By Victor Willoughby, General Mechanical Engineer, American Car and Foundry Company

The transportation facilities of a nation have always provided an accurate gage of its prosperity. The solving of a transportation problem calls for a careful analysis of the products or people to be transported, length of haul and density of traffic. Not many years ago we were almost entirely dependent upon railroad or steamships as our transporting mediums over any except the shortest distances. The advent of the motor truck has materially changed the short haul freight problem, while the privately owned automobile together with the bus lines, are giving all except the long-haul freight and trunk line passenger service a hard struggle for existence.

The automobile has probably been one of the best educators that has ever been invented and its use has so stimulated passenger travel that our desires are becoming more and more cosmopolitan. Take the dining table of today versus that of 30 or 40 years ago and you will find on even the most humble table products from all over the world. These were luxuries three or four decades ago; today they are felt to be absolute necessities. All this means additional traffic for our transportation facilities to handle and the equipment must be that most suitably adapted for its traffic.

Refrigerator Cars

The refrigerator car must take the melons of Colorado or California, place them in New York or Boston in the pink of condition, and the charge for this service must not be exorbitant. Every pound dead weight which this car contains entails the use of extra energy for its transportation. This energy comes from the coal pile. Therefore, one of the car designers' first problems is to keep the weight of the car as low as possible, all things considered.

In order to deliver perishable produce in the pink of condition it must be kept during the days which it is being transported within a narrow range of temperature which may vary as much as 50 to 80 deg. Two important elements of design enter into the proper maintaining of this temperature: (a) the refrigerating agent, and (b) proper insulation of the car.

The refrigerating agent in general practice is melting ice. The cost of this is a transportation charge against the product and may be divided into several parts, such as cost of the ice and salt; cost of handling the ice; transportation of this ice, it being an additional dead load; and the damage that the salt water can do to the car and the roadbed. Therefore, in designing this car it is extremely important that care be taken to conserve so far as possible this refrigerating effort by proper insulation.

Take the design of the insulation; laboratory tests have been made on a large variety of insulating materials. These tests are useful, but are reliable guides only insofar as the insulating material is applied to the car in such a manner that it will stay where put. A new wooden-frame refrigerator car with all joints between the insulation tight and connections between outer and inner walls properly insulated will give results very close to those indicated by laboratory tests. If, however, in the course of operation the joints open up, insulation slips from place, leaving open spots, then the efficiency of the car deteriorates rapidly.

The designer must be careful to see that his construction is such that this insulation will stay where put during the normal life of the car. In doing this he must not overlook the element of weight, because every pound increase in dead weight means a certain amount of coal wastefully used.

Thus due consideration must be given when deciding upon the kind of insulation as to its insulation value versus its weight, versus the ease with which it can be properly secured in a car structure, versus its susceptibility to moisture, and its relative cost weighed against all these elements. A refrigerator car designer has to take all these factors into consideration if he hopes to have a design that will successfully compete in the transportation game. He even should go further and consider the color of paint used on the car, especially the roof, as this has a large influence on heat radiation and heat absorption.

Box Cars

Taking the box or house car, first consideration must be given as to what product is most likely to be hauled. The designer who does not consider the predominating commodity that the car has to transport, giving this first consideration, then carefully weighing all other requirements, is not going to produce a design of which there will be many repeat orders.

One type of freight car which today is undergoing the greatest transition and to which more than its share of attention is being given, is the tank car. Commodities formerly shipped in glass bottles or in carefully crated small containers, are today transported in tank cars.

The Container Car

Another special car which we feel is going to be used extensively when its advantages are appreciated is the container car. Where a manufacturer has consignments to several customers, none of which equal a carload, but which, on the other hand, are shipments equivalent to one-sixth or one-fourth of carload, will have delivered to his factory containers in which he can (for instance, if he is a shoe manufacturer) pack his product in the ordinary individual pasteboard boxes without the expense of cartons or packing boxes now used in l.c.l. shipments. He will fill this container with shoes in the same boxes in which they will appear on the retail shelf, seal this container, have it taken to the freight yard, loaded on a specially prepared car and transported to destination. There the container is lifted bodily from the car and trucked to the customer's receiving platform and unloaded, the container being returned to the car and sent back for the next shipment. In this manner material necessary for manufacturing crates, which, after they are once used, are generally destroyed, is eliminated, together with a marked reduction in the handling of the goods and a big reduction in the possibility of damage to the goods. This scheme of transportation is in its infancy, but indications are that its advantages are being appreciated and we can look in the near future for a marked increase in container car shipments.

In the chlorine industry there are a number of cars designed to carry 15 steel cylinders, each of which holds one ton of liquid chlorine. These cylinders can be removed, empty cylinders placed back, and the car returned for reloading.

The reduction of dead weight is a problem that is being given serious attention. As one instance, note the one-wear steel wheel. Considerable study is also being given to the use of alloys with the hope of utilizing metals of higher strength, and thus effect a saving in dead weight.

As stated, the privately owned automobile and the bus have made great inroads in passenger traffic, especially over moderately short hauls. In congested districts, of course, there is not room for the automobile to handle the masses, with the result that we have highly specialized elevated and subway systems. The study and design of this type equipment is a job in itself.

Serving the largely populated centers we have, commutation trains gain a specialized traffic. Large numbers must be carried quickly and the service absolutely must maintain schedules irrespective of weather conditions. The periods of dense traffic in this service extend over only a few hours of the day, one way in the morning, the other way in the evening. However, reasonable service must be given during the balance of the day. Cars for this service must be comfortable, of large capacity and be of as light weight as possible consistent with safety.

Suburban Passenger Cars

Many suburban car designs have been developed, some of which adhere closely to the road's coaches for through service; others are highly specialized, some incorporating large or numerous doors to permit quick loading and unloading. One road serving Chicago is building a number of cars incorporating a large amount of aluminum, thus effecting a marked reduction in weight. Another road also has in experimental service on one of its lines entering Philadelphia cars utilizing aluminum and its alloys to quite a marked degree. It is a little early to pass on the extent to which aluminum can be successfully utilized in passenger train cars.

Remote branch line service has been hardest hit by the automotive vehicle. The truck is here the freight competitor while the bus and privately owned automobile have made great inroads in the passenger travel. It is still necessary, however, that the roads operate these branch lines, and, as a result, we have the self-propelled car development as an answer to this specialized product. Extreme care must be given to the question of weight, and the designer who does not carefully analyze every detail which goes to make up the structure of his car, is either going to have one too heavy to be economically operated or else a structure which will have weak parts and will fail during service.

Passenger Coaches Too Heavy

The main line passenger car for through service has been influenced less than any other by the automotive vehicle. The designer of this type of equipment, however, must give more consideration to attractiveness and comfort than in the past. Passenger coaches of today are entirely too heavy and cannot be operated as economically as they should be. True, first consideration should be given to safety. Even safety, though, can sometimes blind one to the proper evaluating of the elements entering into the design. The usual construction of a main line coach of today is built around a heavy built-up center sill member known as fish-belly or shad-belly sill, which is in reality like a backbone to the car. This is a perpetuation of the construction used in earlier stages of development, when steel underframes were placed under wooden bodies. At that time it was necessary that the steel underframes have sufficient strength and rigidity to carry the car body and the live load, as well as resist the buffing and pulling stresses.

When the use of steel was extended from the underframe to include the entire structure of the car, most designers still retained the heavy center sills. In the earlier designs of the all-steel car, the load-carrying members were the center sills, assisted by the portion of the side frame from the belt rail down to the side sill, while the buffing shocks were resisted by the center sills only. The superstructure of the car above the belt line was considered as so much dead weight. When the posts were light rolled sections with little rigidity, this analysis was partially true. However, with the development of pressed posts and especially the use of box section posts the side frame becomes not a girder, whose depth is that of the belt rail down to the side sill, but the entire framework of the car is something after the fashion of a tub and it is logical to consider that the steel roof sheets, purlines, deck, side plate and letterboard all form the load-carrying member of the car and that they also, in a limited way, contribute to its shock-resisting strength at the time of a collision.

Does Unlimited End Strength Promote Safety

For easy computation quite a few designers consider the side frame of the car; that is, side plate, letterboard, the belt, rail, side sheathing, and the side sill as the carrying member of the car. Here you have a girder between 7 and 8 ft. in depth, which has in itself ample strength and rigidity to carry all the vertical loads to which the structure will be subjected, and yet not exceed in weight, size or thickness that which it is necessary and logical to use to perform its primary function of protecting against the elements and form a support for the car roof.

A great deal of stress has been placed on making the end of the car so strong that in case of collision the car will not be penetrated. The writer believes that if the end is made too strong the shock from the impact will be such as to throw passengers around in a way to cause more damage than if the car end was not so rigid, but was symmetrically attached so that in case of a collision the vestibule will fold up or crumple and absorb, to a large degree, the force of impact due to collision and cushion the blow. While the car itself may be damaged a little bit more, passengers will be much better protected, which, of course, is the first duty of the car structure.

I have tried to point out a few of the aspects of car design encountered every day. These are additional to the purely engineering computations necessary to determine strength of individual members. We, as builders, of course, see the question of design from a different angle than you who operate and maintain the cars during service. In many ways our problems are the same. The structure which lends itself most readily to ease of maintenance is generally a construction which is easy and economical to build. Because of the necessity of maintaining existing standards, thus keeping to a minimum the repair parts necessary to carry, it is not always economical to utilize the best construction. This is a feature of which the railroad's engineer should be the best judge. However, simplicity of design, as few parts as possible and reduction of weight consistent with serviceability should always be carefully weighed against savings that can be effected by maintaining existing details. Often it is wise to cut loose from existing details and establish new designs for railroad cars.

The question of excessive dead weight is, in the writer's estimation, a vital one and one that should be attacked from every angle, from scrutinizing the size of the smallest detail up to the use of special materials, keeping in mind that every excess pound in the weight of the car will be ton-miles of dead load carried before the car has served its day.

1928 Mechanical Division Convention

The Mechanical Division of the American Railway Association and the Railway Supply Manufacturers' Association has decided to hold the 1928 convention at Atlantic City, New Jersey, in connection with which there will be an exhibit by the Railway Supply Manufacturers' Association, June 13 to 20, inclusive.

Report on Locomotive Design and Construction

The committee on locomotive design and construction of which H. T. Bentley, general superintendent motive power and machinery, Chicago & Northwestern Railway, was chairman reported this year on "standardization of fundamental parts of locomotives; rail stresses under locomotives; use of 3-cylinder vs. 2-cylinder locomotives; provision for expansion of locomotive boilers on the frames, and firebox supports; exhaust steam ejectors; advantages and disadvantages of boiler pressures higher than 200 lb.; and development and use of oil-electric locomotives in railway service." The following is an abstract from the committee's report:

It would seem pertinent to this subject to give a brief history of the 3-cylinder locomotive in the United States, as it dates back at least to 1848. At that time, two 4-4-0 type locomotives were converted to 3-cylinder for the Philadelphia, Wilmington & Baltimore, which is now a part of the Pennsylvania System. From that time up to 1894, twelve 3-cylinder locomotives of various types were constructed in America. Between 1890 and 1900 the Erie and Wyoming Valley Rd. had several 3-cylinder simple locomotives built of the 4-4-0 and 2-6-0 types, which were in service between Dunmore and Honesdale. They demonstrated remarkable pulling power on grades, and were noted for their steady riding. They were in service for several years, but difficulties with crank axles resulted in their being converted to the 2-cylinder arrangement.

Earlier than that, F. W. Webb had in service a number of 3-cylinder compounds on the London & Northwestern Ry. which did not prove very satisfactory. One of that type was tried in America with similar results. H. N. Gresley of the Great Northern Ry. of England introduced 3-cylinder locomotives on that road several years ago. They rank high as to design and workmanship, and it is reported that their performance has been, and still is, satisfactory.

The next marked advance took place in 1909, when the Philadelphia & Reading built a 3-cylinder 4-4-2 type locomotive, followed by two 4-4-2 type and one 4-6-0 type built during 1911 and 1912. These locomotives made some remarkable runs, but difficulties with the crank axles and inside valve motion led to their conversion to the 2-cylinder arrangement.

The early history of the 3-cylinder locomotive is not especially pertinent to its present-day stage of development except in so far as the difficulties encountered in design, construction and operation may have served as valuable experience to aid in the present design. The common features of construction of the locomotive as built by the Philadelphia & Reading in the years 1909 to 1912 are the locations of the 3 cylinders, equal setting of the crank pins at 120 degree intervals on separate axles, the inside cylinder being connected to the leading axle, and the outside cylinders to the second pair of wheels, and the employment of Walschaert gear for the external motion. Joy's gear was used for the inside valve. Independent valve gear characterized the early locomotives of this type, and as the valve gear was placed between the locomotive frames, except on the Philadelphia & Reading, the complicated and inaccessible mechanisms tended to obscure the advantages of 3-cylinder locomotives in the opinion of locomotive designers. Because of these mechanical difficulties, together with those experienced in producing a satisfactory crank axle, the 3-cylinder locomotive of the early design did not become an important factor in the development of railway motive power, and very little was said about it in America until the latter part of 1922, when the American Locomotive Co. converted a 2-cylinder 4-8-2 type locomotive to a 3-cylinder for the New York Central. Several radical departures in design were noticeable on this locomotive in comparison with the earlier locomotives previously mentioned, probably the most important of which was the use of the Gresley gear developed on the Great Northern Ry. in England. This gear made it possible to control the distribution of steam to the center cylinder with an outside motion and without the necessity of adding greatly to the complication of the valve gear parts. This locomotive, after having been in service for several months, demonstrated the possibilities of this cylinder arrangement.

The second 3-cylinder locomotive, a 4-8-2 type built by American Locomotive Co., was delivered to the Lehigh Valley in Oct. 1923. Within 2 or 3 months after it was placed in service, a number of test runs were made which showed fuel economy, ability to make up time with heavy trains, freedom from lurching and vibration at high speeds, and ease in starting, it being possible to get a heavy train under way with a noticeable absence of jerking. Since the installation of these two locomotives, which in a strict sense are the real pioneers of the modern 3-cylinder locomotive in America, there have been 138 three-cylinder locomotives built for various United States railways. Not the least interesting recent development is locomotive 60,000, a 4-10-2 type, built by Baldwin Locomotive Works during the early part of 1926. It is equipped with 3 cylinders of equal diameter, the center one being high pressure and the two outside ones low pressure. The steam distribution is controlled by Walschaert valve gear, with an independent motion for each cylinder, all of which is controlled by one power reverse gear. The two outside cranks are placed 90 degrees apart, and the inside crank is placed at 135 degrees from each outside crank. This is an experimental locomotive, designed and constructed with a view of ascertaining the gain in efficiency obtainable by the use of high steam pressure and high ratios of expansion. It was submitted to an extensive programme of tests on the Pennsylvania Rd.'s locomotive test plant at Altoona, and is now being tested in road service on various railways.

There are many more 3-cylinder locomotives in service in foreign countries than in America, Germany being in the lead with approximately 2,000. In England, there are about 250, and 100 distributed among other countries, making a total of about 2,350. A considerable number of them have been in service from 10 to 15 years.

There seems to be no doubt, therefore, that the 3-cylinder locomotive has some decided advantages over the 2-cylinder design. At the same time, as in most improved mechanical devices, it also carries the usual disadvantages of having an increased number of parts and requiring more care in design and maintenance. However, if the value of the advantages outweighs to a great extent that of the disadvantages, the 3-cylinder locomotive will play its part in reducing the cost of transportation and become more popular.

It would appear that improvements made in material and design of the crank axles have overcome the weakness of this detail in the earlier construction, as the modern 3-cylinder locomotives have been remarkably free from this defect, only one failure having come to our attention of the 138 locomotives in service in the United States.

For the purpose of collecting data for this report, 24 questionnaires were sent out. Thirteen were sent to railways operating 3-cylinder locomotives in America; three to railways operating 3-cylinder locomotives in Europe; and five to prominent railways in America that have no 3-cylinder locomotives in operation, in order to get their views, it being considered not necessary to send out questionnaires to all railways not operating 3-cylinder locomotives. Questionnaires were also sent to the three principal locomotive builders in the U.S.A. Replies were received to all circulars other than those sent to countries outside America, the replies to the latter hardly having had time to reach us. While all of the five roads not operating these locomotives replied, four did not make any comments and one quoted several advantages which rather appealed to them.

The number of 3-cylinder locomotives in service on the different roads in America vary from one to 39. The types also have a great range, as shown in the following tabulation, which gives the number of locomotives for each type reported, together with their tractive powers and factors of adhesion:—

Type	No. of locomotives	Tractive powers	Factors of adhesion
0- 8-0	11	60,000 to 66,300 lb.	4.05 to 3.9
2- 8-2	7	65,000 to 67,870 lb.	3.7 to 3.74
4- 6-2	3	46,400 to 47,100 lb.	3.77 to 4.05
4- 8-2	51	61,000 to 77,600 lb.	3.54 to 4.19
4-10-2	49	78,000 to 84,200 lb.	3.7 to 3.77
4-12-2	15	96,650 lb.	3.67

This brings out the fact that the 3-cylinder principle can be adapted to all of the standard types that are commonly used for modern 2-cylinder locomotives, and in case of one recently introduced type, viz., the 4-12-2, it is scarcely probable that 2 outside cylinders would be seriously considered in combination with 6 coupled pairs of drivers.

The above mentioned locomotives are in hump yard switching service, transfer service, freight, fast freight, milk trains, express trains and passenger. The different roads in answering the question regarding classes of service to which 3-cylinder locomotives are considered best adapted, almost invariably mentioned the service in which the particular road has actually placed the locomotives. Thus we find that one road answered passenger or freight, particularly in mountainous territory; two roads, all classes, but more particularly freight; one road, slow freight service; one road, hump yard switching and moderate speed heavy freight service; two roads, fast freight; one road, fast passenger; and two roads, can be adapted to any kind of service. Three roads gave no answers to this question.

The cylinders of locomotives reported, range in diameter from 22 to 27 in., and are obviously much smaller in diameter than would be required to develop the same power if only 2 cylinders were used. This reduces stresses set up in machinery and frames, allows the reciprocating parts to be much lighter, resulting in less counter-balance in the wheels, and, consequently, in less dynamic augment. Where cranks are set at 120 degrees instead of 90, as on 2-cylinder locomotives, there is a further reduction in dynamic augment owing to the avoiding of the combined effect of two counterbalances are reduced about one-third, thus permitting static wheel loads to be increased by a like amount. Furthermore, the use of smaller cylinders not only reduces the leverage on main axles and crank pins, thus decreasing the stresses set up in these parts as well as in frames, wheels and their component parts, but also permits a greater cylinder capacity within the same overall measurement of cylinders.

At slow speeds the factors of adhesion of the locomotives reported range from 4.19 to as low as 3.54, all but 17 of them being less than 4.0. For 2-cylinder locomotives the adhesion is nearly always well above 4.0. The low adhesion is made possible only by the use of a third cylinder, which produces a more uniform pulling torque. In any locomotive the adhesive weight must be great enough to prevent slipping with the maximum tractive force developed through a complete revolution of the drivers. The increase in percent of this maximum over the average is much smaller for a locomotive with 3 cylinders than for one with 2 cylinders. Hence, for a given weight on drivers, the 3-cylinder locomotive can develop from 10% to 15% more rated tractive effort than a 2-cylinder design, without slipping the wheels.

Restricted cut-off is in use on 3-cylinder locomotives in Europe and has been embodied in these locomotives on 2 railways in America with satisfactory results.

The questionnaire asked for cost of repairs on a ton-mile basis for 3-cylinder locomotives compared with 2-cylinder locomotives in the same service. Four roads answered on this basis, 3 on a mileage basis, and 6 did not answer this question. Of those replying on a ton-mile basis, 3 roads report respective savings of 7.5%, 23.9% and 28% for the 3-cylinder, while the fourth states that the repairs are only 25% of that of a 2-cylinder locomotive. On a mileage basis, the figures furnished by one of the roads shows 0.43% increase in cost for the 3-cylinder, and by another 21.8% saving.

The question regarding fuel consumption for 3-cylinder locomotives compared with 2-cylinder locomotives in the same service was answered by 9 roads, all on a ton-mile basis. The reports show a saving of from 3% to 18% for the 3-cylinder.

In answer to the question, "What percent, increase or decrease in tonnage per 1,000 lb. weight on drivers, do 3-cylinder locomotives haul as compared with 2-cylinder type?" all roads except 2 report an increase of from 3% to 20%. The 2 exceptions are as follows: One road rates the 3-cylinder the same as an equivalent 2-cylinder locomotive; another road gives the same rating for both types on a 0.4% ruling grade, but states that on various momentum grades up to 0.9% the 3-cylinder locomotive shows as high as 9% increase in tonnage.

Two of the three locomotive builders are building 3-cylinder locomotives, both agreeing that they have the following advantages over the 2-cylinder design: 1.—Increased tractive power, greater starting power, more rapid acceleration and lower factor of adhesion, due to more uniform torque produced by 6 power impulses per revolution. For these reasons are equally advantageous in switching, hump or drag, freight or passenger service. 2.—More perfect counterbalance, thus reducing stresses set up in machinery, bearings, boxes, frames, roadbed and bridges, and permitting increase in weight on drivers and greater speed with better riding qualities. 3.—Greater cylinder capacity, with given clearance limitations and roadbed conditions, and, due to smaller outside cylinders, less leverage and stresses in axles, crankpins, frames, wheels and their component parts. 4.—Less slipping, with less tire and rail wear, greater mileage between repairs and between tire turnings, increased gross ton-mile hours, lower cost of maintenance and operation, and saving of fuel and water account of 3 cylinders permitting operating at shorter cut-off for a given power output. 5.—Due to the greater number of exhausts per revolution, exhaust nozzle can be opened wider, thus reducing back pressure, causing a milder and more even draft on fire, and increasing boiler efficiency. 6.—Permits dividing application of driving power of two axles instead of one, thus reducing stresses set up and increasing life of parts affected.

Exhaust Steam Injectors

The subcommittee on present development of exhaust steam injectors reported as follows:—"We have made a survey of this subject and find that injectors of this type are being manufactured by two companies in America, and are being applied on a number of railways, mostly in limited numbers, as is usually the case with new devices; however, in a few instances a considerable number are in use. When first installed in America, these injectors were in an experimental stage, owing to their use in connection with locomotives operating under high steam pressure. Since then considerable advancement has been made towards perfecting them. Indications are in line of economy. However, the committee finds itself without definite information upon which to base a report. Road dynamometer car tests are under way, but have not been far enough advanced to give information sufficient upon which to base a report at this time. The committee is sufficiently satisfied to recommend that the subject be continued for further report."

Rail Stress Under Locomotives

The report referred to the individual paper on the relation of track stresses to locomotive design presented by C. T. Ripley, Chief Mechanical Engineer, Atchison, Topeka and Santa Fe Ry., at the 1924 annual meeting, and also to the report on the subject prepared by a locomotive design and construction committee sub-committee and submitted at the 1926 meeting. The analysis in that report was confined to steam locomotives of the Pacific, mountain, mikado and Santa Fe types. The 1927 report states:—"The sub-committee appointed at the 1927 annual meeting to make a further study and report endeavored to secure more recent information of tests that were conducted during 1926, but on account of the test data not being completed, they were unable to secure it to be embodied in this report.

"With reference to information that has been given out by some of the locomotive builders, relative to low rail stresses produced by 3-cylinder locomotives, we have nothing to substantiate this argument, other than the generally accepted principle that a better balance of moving parts reduces speed effects.

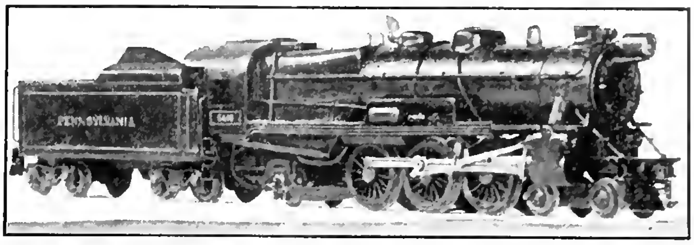
"After reviewing all the available information on this subject, and on account of its scope, it is the committee's recommendation to have a joint committee appointed, comprised of members of the A.R.E.A., who have already made a study of this subject and have accumulated considerable information in connection with it, and the A.R.A. committee on locomotive design and construction, and the committee on electric rolling stock. The latter committee has prepared considerable data on the subject with reference to the effect of electric locomotive operation on rails.

"It is also recommended that the A.R.A. give the necessary authority to have additional tests conducted by some well-equipped university, such as Purdue or Illinois, which is competent to conduct tests of this character, with the understanding that the above committees co-operate very closely with the university selected. Furthermore, if the above recommendations are approved, previous tests and reports should be given consideration, as no doubt the committee will find this information will be of help to them in making their final report and recommendations. When conducting these tests, modern locomotives should be used of the types mentioned above, and in addition thereto, both the 3-cylinder simple and the 3-cylinder compound, and also locomotives equipped with 4-wheel trailing trucks. When making this investigation and tests, the different weights of rails and the different methods of ballasting the roads should be considered, as from observation, it would appear that this feature would play a very prominent part in arriving at definite conclusions on this subject."

Model Pennsylvania K4 Type Locomotive

The accompanying illustration shows a model K4 type locomotive which is the property of our western representative, Elmer B. Tolsted.

The model is of O gauge, or one-quarter inch to the foot. As is well known, it is impractical to incorporate in a model of so small a scale the complete working details of locomotive construction. In the one under consideration, however, a number of patented features have been introduced in order to show such details.



Model Pacific Type Locomotive of the Pennsylvania

The model locomotive operates by electricity from a third rail instead of by steam. The power of the motor is such that the locomotive will run well over 90 scale miles per hour and at the same time haul a load of 15 pounds, which would mean the usual train of cars. The wheels are die cast and special equipment includes automatic couplers, etc. Added realism is given the locomotive when in operation by a smoke producing device located in the smokebox and a colored lamp in the firebox.

The owner of the model plans to have built similar models of the equipment of other leading railroads.

New Radio for Freight Trains to Be Tested

New and specially constructed radio apparatus, which the New York Central perhaps may install soon on its longer freight trains, will be tested before railroad officials and the public some time this month. This demonstration follows a preliminary one made in June, at Schenectady, when a brakeman sitting in a caboose of a New York Central freight train, and an engineman in the cab of a locomotive a mile and a quarter away, talked to each other by radio as easily as two persons would carry on a conversation by ordinary telephone.

The tests were made by engineers of the General Electric Company, which has just constructed a transmitter and receiving set especially for train use.

Caboose and engine carried identical apparatus—a transmitter and a receiver, and both were equipped with a double antenna, one for transmitting and the other for receiving. Communication was established at either end of the train by the simple act of removing a receiver and pressing a button. The pressure of the button called the other station, causing a howling sound.

The test demonstrated the fact that communication may be carried on with comparative ease on a moving train. Radio communication will be most valuable on trains of 70 to 125 cars. On such trains the engineman and conductor are separated by nearly a mile of cars and there is no positive means of communication between them. Signals are usually exchanged by means of a whistle or by flare lights which often fail on account of curves or weather conditions. Should a defect develop, the conductor must either send a brakeman over the top of the long train or by operating a valve, stop the train, either of which would cause a delay. Radio by providing a means of instant communication is expected to expedite train movement.

Railway and Locomotive Engineering

A Practical Journal of Motive Power,
Rolling Stock and Appliances

Published Monthly by
ANGUS SINCLAIR COMPANY
136 Liberty Street, New York
Chicago Office: 168 North Michigan Avenue
Telephone Rector 0746. Cable Address "Locong." N. Y.

Harry A. Kenney, Prest. and Man. Ed. J. Snowden Bell, Associate Editor
W. E. Symons, Associate Editor Thomas P. Kenney, Secretary

LONDON REPRESENTATIVE
The Locomotive Publishing Company, Ltd., 3 Amen Corner, Paternoster Row, London, E. C., England.

SUBSCRIPTION PRICE

$2.00 per year, $1.00 for six months, postage paid in the United States, Canada and Mexico. For other parts of the world, $2.50. Single copies, 20 cents. Remit by Express Money Order, Draft, Post Office Order or Registered Letter.

Mailing address can be changed as often as necessary—always give old and new address, and if you subscribe in a club, state the name of the agent.

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Entered as second-class matter January 15, 1902, at the post office at New York, New York, under the Act of March 3, 1879.

Aerial Transportation Beneficial to Steam Railways

During the past few weeks, the future of our steam railways have been presented in a rather dark picture by two different gentlemen who rank high in their profession. In fact, the actual substance of the opinion of these gentlemen is to the effect that our steam railways are simply due to go out of business in a very short period of time. Thus an investment of say $23,000,000,000 to $24,000,000,000, or probably more, in the finest transportation system in the world, and that is absolutely essential to our national life and prosperity is, according to these prophets, to be scrapped as it were to make room for more modern means of transportation, principally the air ship.

Recent achievements of American heroes in air flights has no doubt somewhat turned the heads of many, who under other conditions might carefully study questions of such great importance before reaching conclusions so vital in their effect on our economic and national life. The motor truck, electric current, and the air ship are not only being advantageously employed in transportation of freight and passengers, but will continue to expand in that field in the future and while in some instances the result has had an adverse effect on steam railway passenger earnings, it may be said that as a whole these additional agencies have been called into use as supplementary to our railways to meet the wonderful increased commercial growth of this great nation, rather than to supplant steam railways through lack of efficiency.

In numerous instances, what may appear to the casual observer as a loss to steam railways, especially in passenger traffic, is in fact a blessing in disguise as it were, as an analysis of freight and passenger earning of railways during the past few years will abundantly testify.

President Cowie of the American Railway Express Company recently announced contracts with five railway companies covering transportation of express matter by air, and this announcement was misinterpreted by some to sound the doom of all express service on steam railways. President Atterbury of the Pennsylvania system has pointed out the fallacy of such unfounded misgivings, explaining that the contracts are an indication of progressive leadership in the transportation field, and embraced no evil foreboding for steam railways at all.

In the November issue of RAILWAY AND LOCOMOTIVE ENGINEERING the question of aeronautical transportation was reviewed in a somewhat condensed form at that time. Great strides have since been made, and no doubt other and greater development will be made in the near future. It should be evident, however, that even with the present and probable future growth of our splendid steam railways, plus the above mentioned auxiliaries, that we will still be hard put to keep abreast of the actual requirements of national growth and expansion.

European nations have far exceeded the United States in developing air transport since the war. In Germany, Holland and England passenger transportation has been found to be both safe and cheap, there being something like 200 schedule routes. Germany seems to have taken leadership in this new development and at present looms strongly as master of the air, spending large sums of money which in pre-war times went to the maintenance of merchant marine, army and navy budgets.

There are now more than 1,000 commercial air planes in service in Europe. The total air routes in the world at present amounts to about 75,000 miles, which includes the transcontinental route from the Atlantic to the Pacific. Of the above mileage 60,000 is in Europe and 45,000 of the 60,000 is in Germany. When we strike our full gait, however, as the result of the stimulating effect of Col. Lindbergh and other national heroes, it is confidently expected that we will equal if not surpass any other nation in the world in the matter of aeronautical transportation.

Until quite recently special high speed trains have been considered leaders in swift transportation, but the rails must now yield to the air on the element of speed. Recently a traveller from New York City to Moscow, Russia, stepped ashore from a floating palace at Cherbourg, France, with 85 hours of rail travel between himself and the Russian capital. Being a man of means he engaged a civilian plane and alighted in Moscow 19 hours after taking to the air, a saving of 66 hours.

Engineering in the last analysis consists of the application of nature's forces to the uses of man and during the next 40 or 50 years it may be safely predicted that steam locomotives, air ships, motor trucks and electric prime movers will expand in their respective fields as their special fitness for and in our national development may suggest, but, the day for sending our steam railways to the junk pile is so far in the distant future, that those of this generation who wish to contribute anything to the sum total of human progress, had better drop this fallacious and destructive bugaboo, and apply themselves to something constructive in character that will be helpful to their fellow man.

Westinghouse Brakes in France

For years a controversy has waged in France as to the best or most suitable power brake to be adopted as standard for continuous freight trains. It is interesting to note that the French Government has recently officially announced that the Westinghouse brake has been adopted for the French railways and that a portion of them will be supplied by Germany on account of reparations. The others will be allotted to French manufacturers.

During the years of the controversy, which embraced commercial, political, patriotic as well as technical and pratical engineering angles, many different types of brakes were tested out in service and much oratory expended in the many conferences. Even now, there is much divergence of opinion as between the technical experts of France and her neighbors, particularly Belgium and Germany with whom the greatest interchange of rolling stock will obtain.

In a long series of practical tests preceding the decision, a modified Westinghouse, the Clayton-Hardy vacuum brake, the Lupkowski and several others were presented for consideration and trial, but it has been understood all along that the Westinghouse was most favorably considered.

The Kunz-Knorr brake which the Germans applied rather extensively during the war was strongly urged. Some time ago Germany proposed to finance the standardization of the Kunz-Knorr on the French Railways on account of reparations, but aside from these conditions being unacceptable to the French Government, there was obviously, at the time, a pronounced antipathy to standardizing a German device on the French railways.

The modified Westinghouse brake has after exhaustive trials proved entirely satisfactory, and as it is interchangeable with the Kunz-Knorr, the Berne Commission has approved its adoption on the same basis.

Aside from the conflicting patriotic and financial influences that played no small part in influencing engineering judgment, there was the plain cold fact for the French people to sonsider, that to standardize and equip their rolling stock with continuous power brakes would cost in the neighborhood of $3,200,000, and the further fact that once a system is adopted it must be considered as permanent, and under the rigid economy essential to their economic life, no chances could be taken in making such huge expenditures.

Obviously, the compromise between conflicting interests as above reflected will work out to the mutual benefit of all concerned, and the problem of continuous brakes, so far as continental Europe is concerned is virtually settled as the Kunz-Knorr and the Westinghouse are the only ones that have received official approval, and no other brakes have been proposed by the countries at interest.

The action above cited may be considered as an endorsement of a system of power brakes that are standard on and successfully function on the greatest railway systems doing the greatest business in the world.

Progress in Fuel Economy

At the annual convention of mechanical division of American Railway Association this year, a most interesting paper was presented on the subject of the development of mechanism for producing furnace draft in locomotive service by Dr. W. F. M. Goss, who on account of extended experience in matters of this kind is unusually well qualified to handle the subject.

Wonderful strides have been made in the development of the steam locomotive during the past 25 years and during recent years the improvements in design, construction and operation of steam locomotives on our American railways has shown such marked advancement as to strongly emphasize our claim of leadership in railway engineering.

Without enumerating the numerous improvements we draw attention to the results obtained in the one single item of pounds of coal burned per 1,000 gross freight ton miles and per passenger car mile which has been as follows:

Year	Pounds Coal per 1,000 Gross Ton Miles	Pounds Coal per Passenger Car Mile
1921	180.2	18.5
1922	178.0	18.2
1923	160.9	17.6
1924	149.5	17.1
1925	140.3	16.1
1926	136.2	15.8

From the foregoing tabulation it will be observed that the reduction in pounds of coal per 1,000 gross ton miles in 1926 over 1921 was 63 lb., or 35 per cent, while the reduction in pounds of coal per passenger car mile was for the same period 2.7 lb., or 14.6 per cent.

The above figures in pounds and percentages when converted into money means that many millions of dollars have been saved in the item of fuel alone. That the amount of money saving may be more clearly understood the total amount paid out for fuel during the years 1923 to 1926 was as follows:

1923	1924	1925	1926
$617,800,000	$471,656,000	$459,465,341	$473,353,928

It may be noted that the total amount paid for locomotive fuel in the four years was $2,022,275,269, or about one-twelfth the value of our railways. Notwithstanding the high standards attained in design, construction and operation there is still room for much improvement in our steam locomotives. One of the weak points that has been sadly neglected is the principal theme of Dr. Goss's paper, which will be found elsewhere in this issue.

As has been frequently pointed out during the past three years in the pages of RAILWAY AND LOCOMOTIVE ENGINEERING, excessive back pressure on pistons and unrestricted action of exhaust steam has cost the railways hundreds of millions of dollars and this unnecessary waste not only is growing to-day, but there seems to be very little effort made to give it the attention that some other features of locomotive design and operations of less relative importance receive. This wasteful feature has been so often pointed out and so strongly censored or condemned that many have despaired of action suitable to its financial importance. If the very valuable and instructive paper presented by Dr. Goss should result in some real constructive progress in this matter, we will gladly add the author's name to those he so generously gave credit for their efforts to improve this most important feature of the steam locomotive.

Here is an opportunity for some one railway company, or possibly two or more railways with the available facilities to step right in and attack this problem in a practical manner, put a stop to unnecessary waste, increase the efficiency of our steam locomotives and save millions of dollars in operating expenses.

A New British Express Locomotive

Elsewhere in this issue there is described a new 4-6-0 type, four-cylinder locomotive built by the Great Western Railway Company of England, which is said to be the most powerful locomotive used in passenger traffic on any British railway.

Our London correspondent has drawn our attention to the comment that has been evoked in the British Press by the advent of the engine which is to be shipped to

America and exhibited at the forthcoming centenary celebration of the Baltimore and Ohio Railroad. It is, therefore, of more than passing interest to American railroad men. The locomotive is indeed a well designed and proportioned machine, but we are rather amused at some of the observations in the British newspapers, particularly those describing it as the most powerful unit ever built and that it is going to show America what locomotives ought to be like.

The handsome finish of the engine which is in bright green, with its imposing polished details, will naturally excite comment on this side of the Atlantic; it will be very interesting to hear what our railroad men will have to say about this latest example of British locomotive engineering.

Tank Locomotives Here and Abroad

By Arthur Curran

In the year 1902, the Central Railroad of New Jersey placed in service 12 suburban tank engines of the 2-6-2 type; and, in 1903, eight more of the same design. All were built by the Baldwin Locomotive Works and are, presumably, still in service. Though they must be familiar to countless numbers of people, a brief reference to them will help to explain much that is to follow.

The cylinders are 18x26 inches, drivers 63 inches in diameter, and total weight 169,900 lbs. The steam pressure is 200 lbs., grate area 54.5 square feet, and heating surface 1,821 square feet. The tractive force is 22,800 lbs., and the tank capacity 3,000 gallons.

In September, 1903, the Great Western Railway of England introduced a similar design, which is of such interest as to deserve notice in any record of locomotive engineering. The first engine received the number 99, but subsequently was re-numbered 3,100, the designation by which the entire class is now known. In its ultimate form, this class included the following dimensions: Cylinders, 18½x30 inches, drivers 68 inches, total weight 182,640 lbs. The steam pressure is 200 lbs., grate area 20.56 square feet, and heating surface 1,670.15 square feet. The tractive force is 25,670 lbs. and the tank capacity 2,000 (English) gallons; pony truck wheels 38 inches and radial truck wheels 44 inches in diameter.

Originally, the Central Railroad of New Jersey engines had slide valves; some later receiving piston valves and superheaters. From the first engine, the G. W. R. class has had piston valves; and all have superheaters today.

As now running, the 3,100 Class differs in certain details from the design of 1903; but the more important features are common to both.

If I am not mistaken, the Long Island Railroad purchased a few tank engines of the 2-6-2 type from the Baldwin Locomotive Works; though what became of them I don't know.

Tank engines of the 2-6-6 and 4-6-4 types are still in use in America; as well as various other wheel arrangements; though some of these are engaged in industrial service of one sort or another.

The point is that, for simplicity of construction combined with good starting power and ability to accelerate satisfactorily, the 2-6-2 has proved to be a very useful tank design, both at home and abroad.

The Great Western Railway of England found the type so handy, in fact, that two other classes were built, both of which were smaller than the original design.

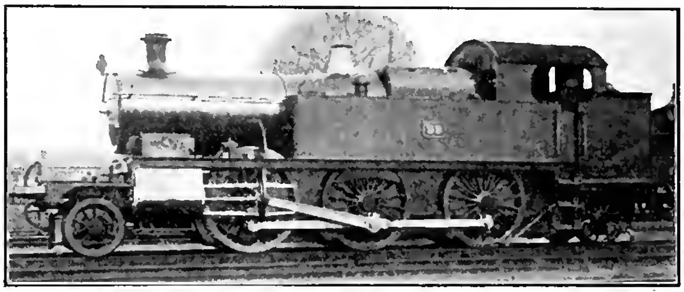
The 4,500 Class has 17x24 inch cylinders, 55½ inch drivers, weight 129,480 lbs., steam pressure 200 lbs., grate area 16.6 square feet, heating surface 1,191.45 square feet, tractive force 21,250 lbs., and tank capacity 1,000 (English) gallons. There are pony trucks at both ends of this class, with 38-inch wheels.

The 4,400 Class has 49½ inch drivers, weight of 124,700 lbs., and tractive force of 20,195 lbs.

Both of these classes are very useful on branch lines having old bridges and light rail.

According to the latest available records, there are 200 tank engines of the 2-6-2 type on the Great Western Railway of England. The number of each of the three classes is not specified, however; though the largest is certainly fairly numerous.

For the benefit of those who may be interested, a photograph of No. 99, the pioneer 2-6-2 tank engine of the Great Western Railway, is presented herewith. I think it will be admitted that the engine presents a workmanlike appearance, and that it certainly is the equal of any similar design constructed in America. In point of fact, it was, in certain respects, superior to its American contemporaries of the same type.


Tank Engine of the Great Western Railway of England

Furthermore, this design was included in a very able programme of motive power standardization which has since proved of immense value in promoting efficiency on the Great Western Railway. Incidentally, it is this settled and carefully considered motive power policy which places the Great Western Railway in a class by itself in Britain, and makes that line of unusual interest to the thoughtful and broad-minded American student of locomotive engineering.

In the work of providing "heavy power," the American designer stands pre-eminent. Our real problem proceeds from the difficulties attending the operation of branch lines and certain divisions over which the movement of local traffic is light.

On the Great Western Railway a tank engine may be used either in passenger or "goods" traffic. Such an engine as, for example, the one illustrated herewith, can handle 100 "wagons," if necessary, over a run within the limits of its tank and bunker capacity. It could, with equal facility, "take a turn" at a heavy suburban run. It will thus be seen that the range of usefulness of such an engine is considerable; and it will be understood, readily enough, why such classes of power are so successful abroad.

I recall that, fifteen years ago, the gas-electric car promised much. I read a great deal of literature on the subject, and wrote some myself. However, you never can tell! Being wise, after the fact, is a great Yankee pastime; though one which does not help much in the world's advance.

Before concluding, I beg to offer one thought which, as it seems to me, is worth pondering. There have been locomotive designs which made a great furore for a year or two, and then dropped out of sight. Those which have stood the test of time are the ones which are most deserving of attention and most likely to prove reliable in the future.

Diesel Traction for Railroads*

The Design, Construction and Maintenance of Diesel Engines and a Consideration of Their Application to Certain Railroad Services

By WILLIAM ARTHUR
Manager, Traction Division, American Brown Boveri Electric Corporation, Camden, N. J.

The development of the Diesel oil engine has introduced new possibilities and many railroads are utilizing this latest form of traction, employing Diesel engines carried on the traction unit itself. More than 50 Diesel locomotives and rail cars are already either in use or under construction in different parts of the world.

In the most usual case the traction unit consists of a Diesel engine driving an electric generator, which in turn is connected to electric motors carried on the trucks in a manner similar to that employed in ordinary electric cars and locomotives. In other cases the drive is through gears. The advantages of "Dieselizing" certain railroad services may be ummarized as follows:

Elimination of Smoke and Noise. The Diesel unit shares these advantages with its electric rival, and with good design operates smokelessly and without undue noise under all working conditions. It therefore possesses advantage for terminal work and for use in switching services in locations surrounded by valuable residential property, similar to those enjoyed by electric traction units.

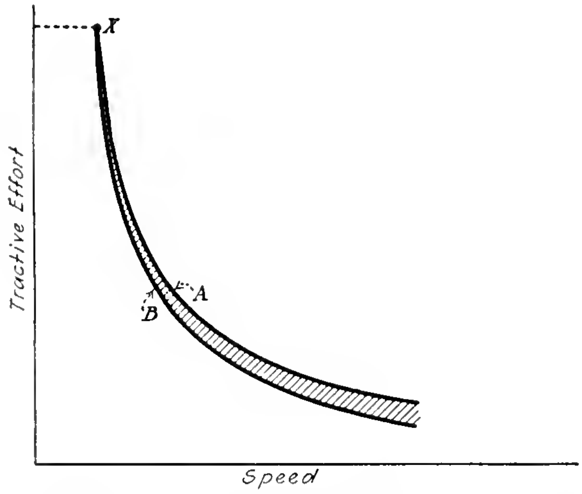


Fig. 1 Speed vs. Tractive Effort, Diesel and Electric Locomotives

Elimination of Terminal Delays. The need of elaborate coaling and water stations, ashpits, etc., together with the apparatus and services dependent upon these features, is eliminated. The Diesel unit is ready immediately for service, and no time is lost in getting up steam or in the various other "hostling" services so necessary with team locomotives. In this again it is similar to the electric locomotive.

Economy of Installation. When compared with straight electric traction the need of expensive power stations, substations, transmission lines, and overhead or third-rail contact systems with their accompanying costs and dangers to life, is done away with. The Diesel unit is self-contained; it carries its power station on its own back. The economics in each case have to be separately studied, but the advantages of the new form of traction, particularly for branch lines and for switching services, are already well demonstrated in this country and in Europe, and larger units are now being introduced into main-line road services.

Fuel Economy. The fuel cost, which of course with all forms of traction is one of the major items of expense, is much reduced and works out in round figures for the same service as follows: the steam locomotive 100 per cent; the electric locomotive 50 per cent, and the Diesel locomotive 20 per cent. On the basis of thermal efficiency at the rail: the steam locomotive 5 to 9 per cent; the electric locomotive with modern power stations and transmission systems, 10 to 12 per cent; and the Diesel electric locomotive, 22 to 25 per cent.

The problems that arise in connection with Diesel traction apparatus come under two general headings:

a Operating problems
b Problems of design and general arrangement.

Of course these matters are closely related, in fact in practice they cannot be separated; nevertheless for the sake of clarity the author will herein discuss them separately.

Operating Problems

Diesel traction differs from electric traction in that with the latter where energy is taken from an overhead wire or third rail, there is usually a large power plant to draw from and from which, for short periods, large overload demands can be made, whereas with the former there is a definite limit fixed by the horsepower capacity of the Diesel unit itself. In practice, a Diesel engine is given a certain normal continuous horsepower rating at normal speed and is capable of overloads of only 20 to 25 per cent for short intervals. It shares this limitation with the ordinary steam locomotive, although recent developments in Diesel design are tending to remove it and extend the overload capacity to a point thought impossible only a few years ago.

On the other hand, the Diesel unit possesses the ability (when combined with an electric transmission system) of translating its full rated horsepower into either high tractive effort at low speed, or into the equivalent high speed at lower tractive effort. In this, like the steam locomotive, it is markedly superior to the electric locomotive operating under a fixed voltage in overhead wire or third rail. This can be better understood by referring to Fig. 1. Here *A* represents the constant-horsepower line which can be closely followed with either a steam or a Diesel locomotive, and *B* represents the condition which obtains with practically all forms of electric locomotives. For instance, if the electric locomotive is designed and geared to deliver its full rated continuous horsepower output at the tractive effort and speed corresponding to the point *X*, then at higher speeds there will be a marked falling off in tractive effort which, in certain instances, will amount to as much as 30 per cent. Electric locomotives must therefore be designed very closely and to some extent limited to the particular service for which they are intended. This is not the case with Diesel-electric locomotives. This inherent flexibility of the latter type is a valuable asset in railroad operation, where in practice tonnage ratings are determined not merely by considerations of ruling grade but by schedule requirements as well. The shaded area between curves *A* and *B*

A paper presented at the Spring meeting of the American Society of Mechanical Engineers.

can, in the case of the Diesel-electric locomotive, be entirely filled in by reason of the flexibility of the voltage control which is possible.

Summarizing this portion of the paper, it may therefore be said that the Diesel-electric locomotive possesses most of the advantages of both steam and electric locomotives, but without some of the disabilities of each.

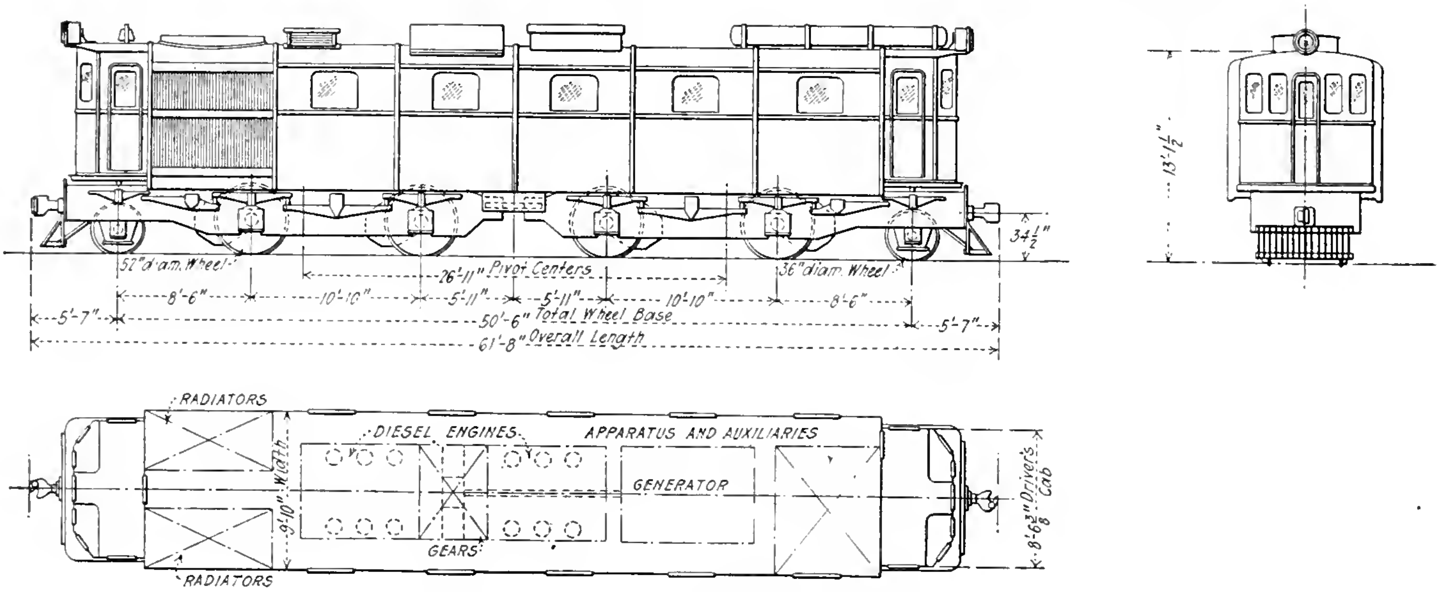


Fig. 2 Diesel Unit Specially Designed for Traction Work

Problems of Design and Construction

Diesel-Engine Types. The engineer interested in the design of Diesel traction apparatus is confronted with a multiplicity of types of Diesel engine from which to choose—2 or 4 cycle, single or double acting, with air injection or with solid injection, with 4, 6, 8, or 12 cylinders arranged in line or in V-construction, with vertical, horizontal, or radial types. Each possesses certain advantages and disadvantages in specific situations; the whole art is developing rapidly, and interesting and significant experiments are under way in the U.S.A., in Sweden, England, Russia, Germany, Switzerland, France, Italy, Africa, and elsewhere.

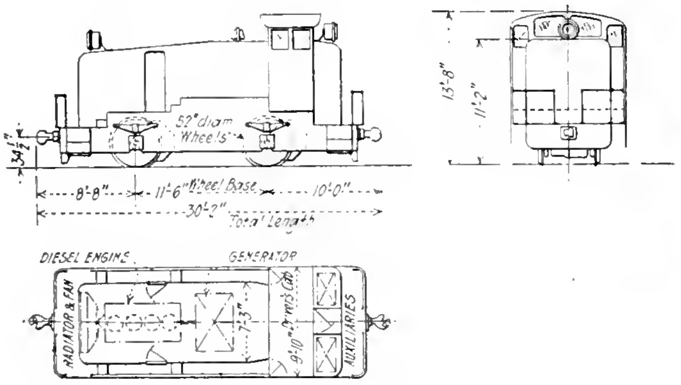


Fig. 3 Smaller Diesel Unit Designed for Switching Service

The author has recently completed a tour lasting more than a year, made expressly for the purpose of studying the outstanding developments in the U. S. A. and in Europe. He was given opportunity to visit practically every important railroad or manufacturing establishment interested in this kind of development, and the present paper embodies some of his findings and conclusions based upon this study.

In considering Diesel-engine types the first choice has to be made between:

a 2-cycle types versus 4-cycle types
b Air-injection versus solid-injection types.

The chief advantage of the 4-cycle types over the 2-cycle is that no scavenging pump is required. This pump is a relatively large and costly piece of apparatus, requiring considerable power, usually about 6 per cent, to drive it. The chief advantage claimed for 2-cycle operation is that a reduction in total weight and cost takes place. In theory this should be so, but in practice in a multiplicity of designs studied by the author this advantage does not seem to have been realized, one of the chief reasons being that due to the need for effective scavenging with 2-cycle types, lower piston speeds are necessary, and total weights and costs increase in consequence.

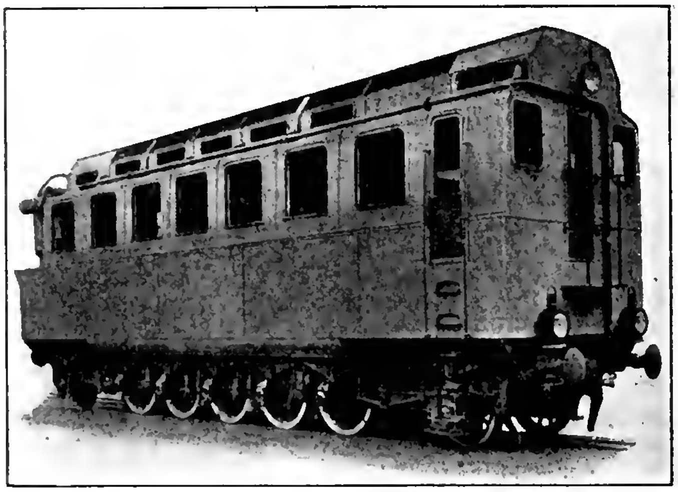


Fig. 4 A Modern European Diesel Locomotive

With air injection the fuel oil is blown into the combustion chamber by air at high pressure, usually at about 850 lb. per sq. in. This requires an air compressor of special design, coolers, pumps, etc., and other expensive apparatus. Moreover, to drive the compressor takes 10 per cent of the total power. With solid injection, however, the oil is squirted directly into the cylinder at each stroke, requiring for this purpose only a small simple and relatively inexpensive oil pump. Air-injection types are therefore inherently more complicated and expensive than solid-injection types.

The chief disadvantage of solid injection is that if the quality of the fuel oil is poor, and contains, for instance, much solid matter, such as asphalt, ashes, etc., trouble may result from the clogging up of the small pinholes through which the oil is injected. Unequal explosions then take place and dangerous pressures become a possibility. This is an important consideration in marine work, for a ship cannot always control the source of supply of its oil and may have to use what it can get. This factor is, however, not of equal importance in land traction work, where usually oil can be obtained of a uniform quality. All things considered, airless- or solid-injection types are to be preferred for traction purposes.

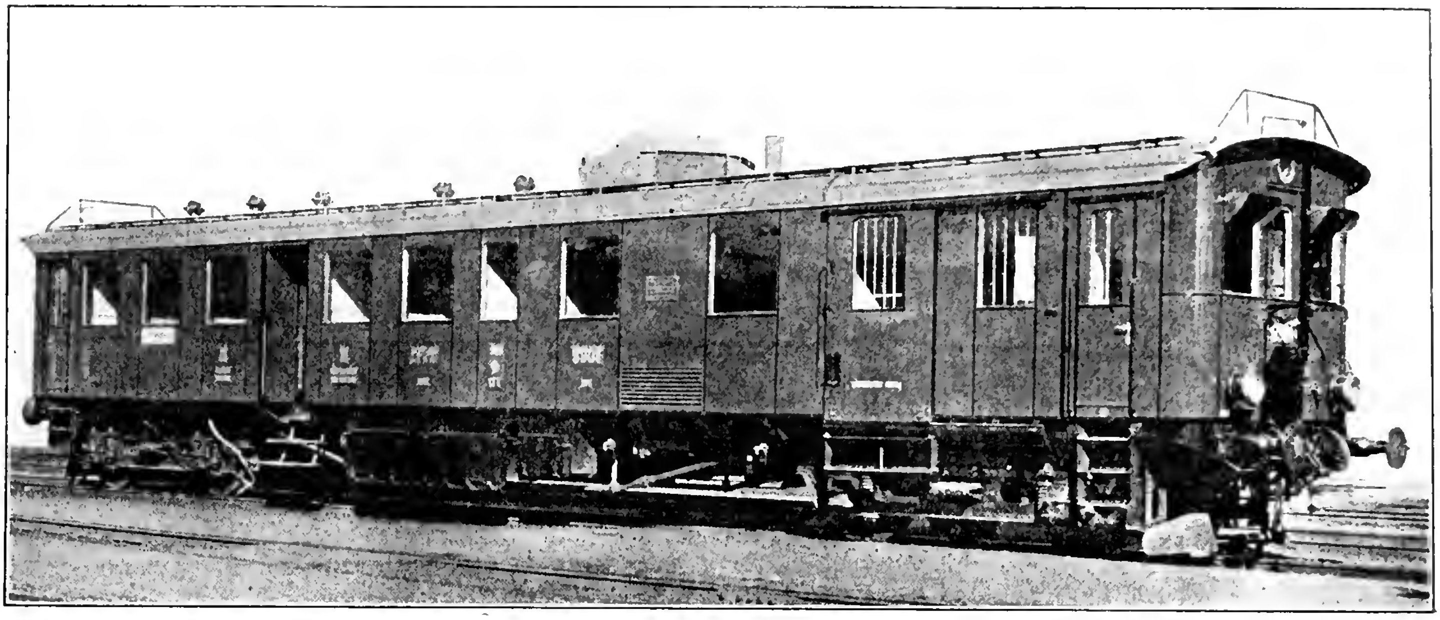


Fig. 5 One Type of European Rail Car

Weight and Speeds

Diesel locomotives and rail cars in the past have been notable for their relatively large weight and consequent high cost, amounting in certain instances to from two to three times that of an equivalent steam locomotive. This condition has arisen from two general causes. First because no Diesel engines had heretofore been developed specially for traction purposes and the locomotive designer was forced to take some existing relatively low-speed and heavy unit designed originally for submarine or stationary purposes and utilize it for traction. Similarly for the electrical requirements, generator, motors, etc., with consequent increase in the weight of all contributary apparatus such as mechanical structure, trucks, frames, etc. Secondly, it has been thought sufficient to simply take a Diesel engine, a generator, motors, and control, together with the necessary fuel and other storage tanks and apparatus, locate and connect them together in a suitable mechanical frame and call the result a Diesel locomotive. In consequence, weights have reached as high as 400 lb. per b.hp. as compared with less than half of this amount for an equivalent steam locomotive. Even in one of the best and most successful recent American designs, employing a 600-hp. Diesel engine, the total weight is 100 tons on drivers, giving 333 lb. per b.hp., or only 6 hp. per ton on drivers.

In certain instances, where the service for which the locomotive is designed is one wherein large tractive effort at relatively low operating speeds obtains, i.e., in switching services and where weight is necessary for adhesion purposes, these high weights per horsepower may be justified; but even in these cases it is doubtful if a substantial decrease in weight would not increase the "liveliness" of the unit—a characteristic most useful and necessary in such services.

The author has just completed designs for a number of Diesel-electric locomotives for use on American railroads in which he has endeavored to avoid these deficiencies and limitations; and by utilizing a Diesel unit specially designed for traction work, by close regard to the interdependence of parts, i.e., by using the Diesel frame in part to support and supplement the main locomotive frame by designing and dovetailing the Diesel engine and its generator into a composite unit, thereby shortening the length of the whole locomotive in short, by coordinating and combining the best American and European practices, we obtain the unit as illustrated in Fig. 2.

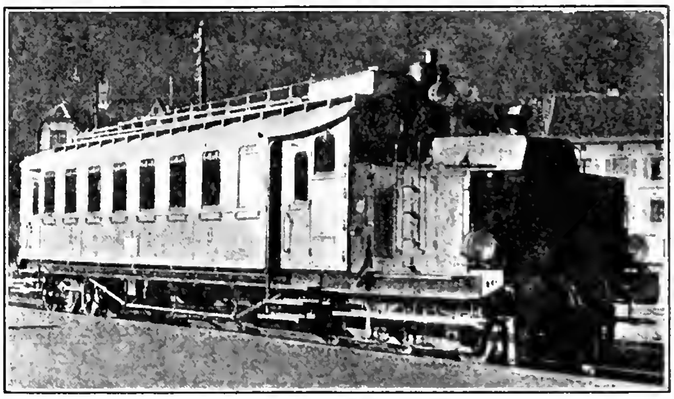


Fig. 6 Another Type of European Rail Car

The general characteristics of this locomotive are:

Track gage..............................	4 ft. 8½ in.
Diameter of driving wheels.............	52 in.
Diameter of guiding wheels.............	36 in.
Rigid wheelbase........................	10 ft. 10 in.
Total wheelbase........................	50 ft. 6 in.
Overall length.........................	61 ft. 8 in.
Output of Diesel motor, continuous......	1600 hp.

Output of Diesel motor, maximum	1850 hp.
Weight of Diesel and electric equipment, including 9000 lb. of fuel and 2200 lb. of cooling water	164,000 lb.
Weight of mechanical part	132,000 lb.
Total Weight	296,000 lb. = 148 tons
Weight on drivers	220,000 lb. = 110 tons
Gear ratio	23:77
Tractive effort at wheel rim, continuous	13,400 lb.
Corresponding locomotive speed	34.6 m.p.h.
Tractive effort at wheel rim, 1 hr.	17,800 lb.
Corresponding locomotive speed	26.0 m.p.h.
Tractive effort at wheel rim, maximum	35,000 lb.
Maximum locomotive speed	56.0 m.p.h.

It will be noted that 14.5 b.hp. per ton of weight on drivers has been obtained. The weight on drivers per continuous b.hp. developed is 138 lb., and for the total locomotive, 185 lb. per b.hp.

The locomotive is designed for road service and for use in either freight or passenger duty by suitable changes to the gear ratio.

A smaller unit designed for switching services is shown in Fig. 3. The general characteristics of this locomotive are:

Track gage	4 ft. 8½ in.
Diameter of driving wheels	52 in.
Wheelbase	11 ft. 6 in.
Overall length	30 ft. 2 in.
Output of Diesel motor, continuous	400 hp.
Output of Diesel motor, maximum	500 hp.
Weight of Diesel and electric equipment, including 1320 lb. of fuel and 800 lb. of cooling water	54,000 lb. = 27.0 tons
Weight of the mechanical part	55,000 lb. = 27.5 tons
Total weight	109,000 lb. = 54.5 tons
Gear ratio	16:84
Tractive effort at wheel rim, continuous	9000 lb.
Corresponding locomotive speed	12.4 m.p.h.
Tractive effort at wheel rim, 1 hr.	13,200 lb.
Corresponding locomotive speed	8.4 m.p.h.
Tractive effort at wheel rim, maximum	27,500 lb.
Maximum locomotive speed	28.0 m.p.h.

An intermediate unit suitable for terminal switching and lighter road services has the following general characteristics:

Output of Diesel motor, continuous	800 hp.
Output of Diesel motor, 1 hr.	1000 hp.
Weight of Diesel and electric equipment, including 4500 lb. of fuel and 1320 lb. of cooling water	93,000 lb.
Weight of mechanical part	85,000 lb.
Total weight	178,000 lb.
Weight on drivers	119,000 lb.
Tractive effort at wheel rim, continuous	6,700 lb
Corresponding locomotive speed	34.6 m.p.h.
Tractive effort at wheel rim, 1 hr.	8900 lb.
Corresponding locomotive speed	32 m.p.h.
Tractive effort at wheel rim, maximum	17,500 lb.
Maximum locomotive speed	56 m.p.h.

Fig. 4 is representative of modern European Diesel locomotive practice and Figs. 5, 6, and 7 show two types of European rail car.

The Diesel engine utilized in the rail car shown in Fig. 5 is illustrated in Fig. 8.

Leaving now problems of general design for a more detailed consideration of the subject, certain new problems arise in Diesel traction apparatus which have to be very carefully studied in each case. These are:

1. The cooling problem—that is to say, the dissipation of the waste heat generated in Diesel motors.
2. The method of transmission of power from the Diesel prime mover to the wheels; and
3. The vibration problem.

The Cooling Problem

The importance of this can be at once appreciated when it is remembered that in the operation of a Diesel motor high pressures and high temperatures are generated, pistons, cylinder walls, exhaust valves, etc., have to be artificially cooled, and that in the final result approximately only one-third of the energy in the fuel oil reappears as useful work at the main shaft, another disappears with the exhaust gases, and the final third reappears as heat which has to be gotten rid of in some way by radiation.

In an average case approximately 2,500 B.t.u. have to be dissipated per hour per b.hp., and with a locomotive of, say, 1,000 hp. the amount of energy to be dissipated by the cooling system constitutes a real problem.

There is great diversity of opinion as to the best way to solve the cooling problem, also as to whether to use natural draft, fans, or forced draft; whether to use the automobile or tubular type of radiator; whether to use oil or water or no cooling at all for pistons; whether to drive the fans directly or by individual electric drive or by an exhaust-gas turbine through gears; how to best arrange the apparatus on the locomotive or rail car, having regard to the need for repairs or removal of the main Diesel unit, etc. All of these are questions which have to be settled in each individual case, and depend so much upon the horsepower involved, schedule speeds, local weather and temperature conditions to be coped with, etc., that is not possible to give a general answer to all of them.

There is, moreover, a relation between the area of the radiator surface and that of the combustion surface. A ratio of from between 30 and 40 to 1 seems to meet most cases. As stated, however, these matters have to be studied and settled in each individual case. Enough has been said to indicate the general nature of the cooling problem.

The Transmission Problem

The Diesel motor is a prime mover which cannot start itself. It has to be started by auxiliary means and run up to a certain speed, after which it will maintain itself in motion. As already pointed out, a steam locomotive is one of the most flexible pieces of apparatus ever devised for traction purposes. Subject only to the limits of its steaming capacity, it can translate its horsepower into either tractive effort or speed to any reasonable degree desired, merely by varying its cut-off and mean effective pressure. It can exert its maximum tractive effort right at the start and when it is most needed, and then later, when the train is once accelerated, can utilize its full horsepower in the form of reduced tractive effort and increased speed. To a lesser degree, as explained, the electric locomotive can do the same, but the direct-connected straight Diesel locomotive cannot. It is necessary to interpose between the Diesel main shaft and the wheels some form of transmission device to make up for this inherent deficiency of the Diesel motor. In this connection it may be mentioned that much developmental work is in progress in Europe and elsewhere looking to extend the flexibility of Diesels, and that substantial gains have already been made.

There are five general methods of transmitting the torque from the prime mover to the wheels. These are:

1. By direct mechanical drive through a clutch or clutches.
2. Through mechanical gearing.
3. Through hydraulic gearing.
4. By mixed systems in which better steam or compressed air is used to augment the flexibility of the Diesel unit at starting.
5. By electric transmission.

Direct Drive is not practical because of the reasons above referred to, although several attempts have been made to utilize it. The Sulzer Company built a locomotive with direct drive but it was not successful; others have tried it and failed, and we can safely dismiss further consideration of this method.

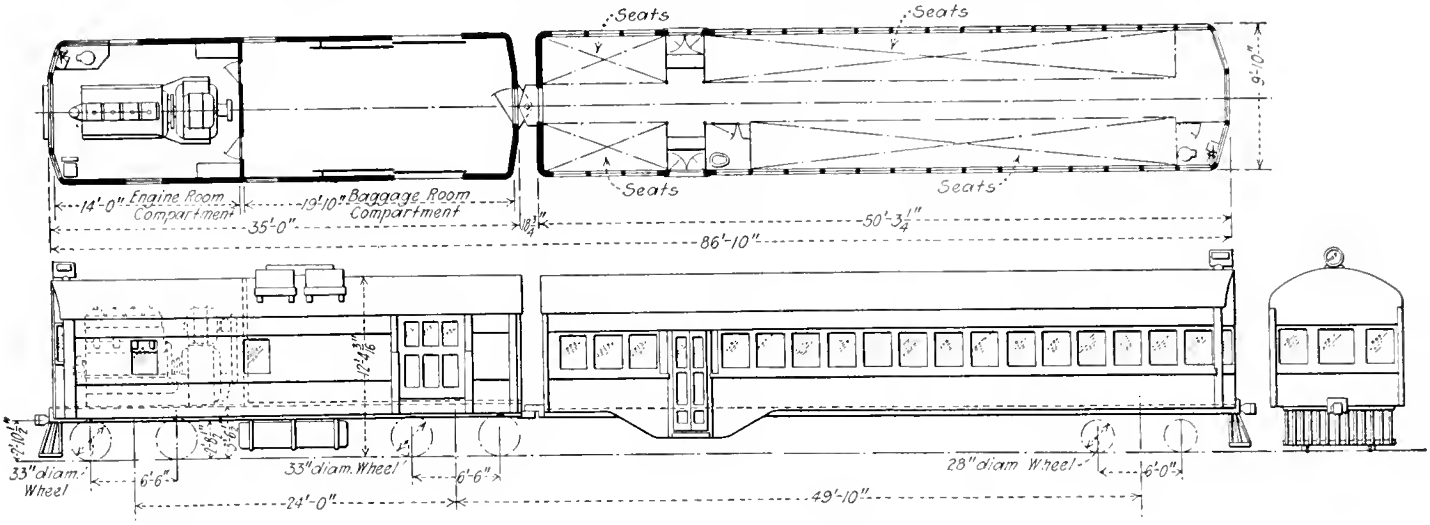


Fig. 7 A Third Type of European Rail Car

Mechanical Gearing is practical, but at present is limited to smaller apparatus, say, below 300 hp., because of the very heavy stresses on the gear teeth, particularly when a train is suddenly started; and also because of the difficulty in designing a clutch which will cope successfully with these large forces. Possibly progress will take place in this direction in the future, for many interesting and courageous experiments are under way in the United States, in France, Switzerland, Germany, and elsewhere. It would be going too far afield to enumerate these.

Hydraulic Gearing offers possibilities and usually consists of a number of primary pumps or pistons delivering oil under pressure to a series of secondary pumps or pistons, the stroke or cubical dimensions of which can be varied at will, thereby permitting an infinite variety of speed changes. There are many types, of which the Lentz, the Hele-Shaw, and the Schneider are the best known. The Schneider gear, developed by the Swiss Locomotive Works at Winterthur, is one of the best. A 500-hp. unit weighing 11 tons has been built and has an efficiency of 85 per cent. Bigger sizes up to 1,600 hp. are, it is claimed, practicable. Such apparatus is, however, quite heavy and expensive, and has not yet been tried out on any large scale. There are unsolved problems with regard to free coasting, reversing, etc. Development work is still in progress. The fact that so many new types and variations of the same basic idea are being produced, none of which gets very far, is indication that the problem is not yet completely solved.

Special Forms of Mixed Transmission Systems have been developed and are being tried out. These are:

a. The Still System in England, whereby steam (from a steam boiler) is used to supplement the Diesel deficiencies at starting and during acceleration.

b. The Zarlatti System and the Cristiani System (both in Italy), wherein compressed air and compressed steam are used in separate cylinders as a steam locomotive and so supplement the Diesel prime mover when necessary.

Electric Transmission in the present state of development is, in the author's opinion, and for all except the smallest sizes, the only one we can now safely adopt. General opinion in Europe largely concurs in this. Its use simplifies the starting and removes the need of reversing arrangements on the Diesel prime mover, all reversing, of course, being executed in the most simple manner by changes to the motor leads. Electric transmission permits the Diesel motor to be run at its most efficient speed at all times; all train-speed control being taken care of by voltage variations on the generator, and where necessary by series-paralleling and field-control arrangements on the motors. Electric generators and motors are standardized pieces of apparatus of high efficiency and great ruggedness. We know exactly what they can be counted on to do under any ordinary circumstances. Exact figures are not available, but from such studies as he has made, the author believes that ultimately very little difference in cost or weight will be found between electric and hydraulic methods for the larger types, although there may be cases where in smaller units mechanical gears will show a lower first cost and weight. These alternatives should of course be carefully studied in each case as it arises. For reasons given, however, it is felt that on the whole electric transmission is the best solution for all but the small sizes, and even in these it should be seriously considered because of the many other incidental and fundamental advantages which its use makes possible. The advantages of electric transmission are becoming more and more appreciated, and it would not be surprising to see it universally adopted in the next few years for all Diesel traction apparatus excepting the very small units.

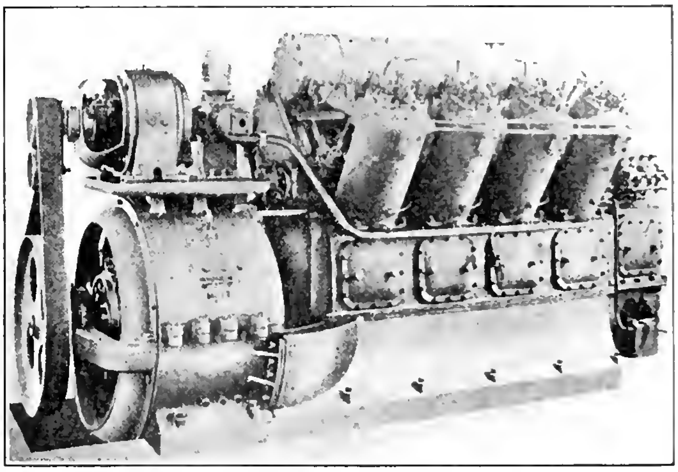


Fig. 8 Diesel Engine Used in Rail Car Shown in Fig. 5

The Vibration Problem

Diesel traction is a relatively new branch of engineering and the combination of high Diesel speeds and high unit pressures leads to new and to a large degree unforeseen results.

One of the definite facts that has been developed by recent practice is that the problem of vibration and critical speeds becomes of great importance. An accelerating and rotating mass—as, for instance, a Diesel motor which is being speeded up—passes through a series of critical speeds, at which points the value of the forces brought into play may be many times greater than normal. The critical speeds may be below the normal speed and therefore the unit must always pass through these on getting up to full speed. These values change as the apparatus attached to the main shaft is changed; and a Diesel may operate perfectly alone, and yet when connected, say, to a generator on the same shaft (as in Diesel-electric locomotives), may with faulty design develop undesirable and unpleasant vibrations.

The matter of vibration becomes of even more importance when Diesel rail cars are considered, for with faulty design the resulting noise and unpleasantness make the car unpopular with the public.

Arrangements are usually made so that in winter if the unit stands for more than a few minutes, the radiators automatically empty themselves into a cooling-water storage reservoir located inside the vehicle. A small electric heating element is sometimes provided to be used in emergencies and where the stop in cold weather is likely to be of long duration.

The storage tank should of course be located at a point below the Diesel cylinders, in order that there may be no risk of cracking the cylinder walls. The exact arrangement must be studied in each individual case, for in certain instances an electric heating unit might put too much strain on the battery, making it necessary to provide other means—possibly a small oil-fired heating unit.

The art is still too new for there to be much real information available as to cost of maintenance; also types vary so much that such information would in any event be of little value. This much can be said, however: Any of the well-known makes of Diesels, either in this country or in Europe, operate quite reliably. This is true of either 2-cycle or 4-cycle types or those with air or airless injection. Some wear and tear of course takes place. Exhaust valves are subject to high temperatures and pressures and need inspection periodically. About two weeks a year should be allowed for general overhaul.

In considering the problam of starting Diesel motors for traction apparatus, one should differentiate between locomotives of large size and locomotives of small size or rail cars; the problem also changes, depending upon whether or not the service is one requiring frequent stops.

There is a great difference of opinion on this whole matter. Some manufacturers prefer air starting, using all of the cylinders for this purpose; others use only a few of the cylinders or possibly one cylinder; still others use a separate air motor geared to the main motor, the advantages of the latter arrangement being that the cylinder walls are not cooled by the air at the moment of starting and a quicker start can thereby be made.

The problem of starting is tied in with that of the method of transmission adopted, for with apparatus of moderate size, if, as is expected, electric transmission is to be used, then in certain cases it is simpler and better to utilize the generator as a starting motor and provide a battery for this purpose. For large units, however, the weight and cost of a battery may be prohibitive.

In locomotive services involving long runs and few stops it would not be necessary to start the Diesel frequently. In fact, it is conceivable that one might start it and keep it running for most of the day in such services.

Every manufacturer is of course striving to reduce his weight per brake horsepower, particularly for traction or submarine work. One of the chief ways of reducing weight is to increase the piston speeds. The limit at present seems to be about 1,250 ft. per min.

Revolutions per minute of Diesel apparatus vary very much. Most of the light-weight, high-speed Diesels hitherto built were designed originally for submarine purposes and usually ran at about 450 r.p.m. The recent tendency is, however, to increase speeds very much, and those of from 600 to 1,000 r.p.m. are not now common.

Pressures Used in Diesel Apparatus—Fuel Consumption

In general, the compression in Diesel cylinders varies from 500 to 600 lb. in European practice, although in the United States the pressures are somewhat lower.

The chief problem in the operation of a Diesel motor from the point of view of fuel consumption is of course to insure that complete combustion takes place. With air-injection types this is taken care of in the most thorough manner by completely breaking up the oil by means of the high-pressure injection air.

In general, it may be safely said that today there is not much difference in fuel consumption between air-injection and solid-injection types, and a fuel consumption of 0.4 lb. of fuel oil per b.hp. is obtainable under ordinary conditions with either type.

The author believes that the next few years will show a marked increase in the number of Diesel applications to specific railroad problems, as, for instance, where bad water conditions obtain, and particularly to switching service, to branch lines, and to a lesser extent to heavy main-line and terminal services. With larger production and closer attention to design features, cost and weights will tend to reduce. At the same time it is fairly certain that capacities will increase, which, together with multiple-unit operation, will render possible handling of the heaviest freight and passenger trains.

The total capital expenditure to be made in "Dieselizing" a railroad will be less in certain instances than with any form of electrification; this expenditure may be made gradually, and, by being spread out over a number of years, the financial strain sometimes necessitated when a complete electrification is undertaken will be avoided.

Railroads Reduce Debt to Government

Railroads have paid into the United States Treasury during the fiscal year ended June 30 a total of $89,316,810 in principal and interest on their indebtedness arising from the period of Federal control and the loans made by the Interstate Commerce Commission afterward, according to figures made public by the Treasury Department.

This leaves a total of railroad indebtedness of $230,484,076. Of the amounts paid, $68,628,774 was on account of principal.

The Boston & Maine liquidated its indebtedness under Section 7 of the Federal Control Act and Section 207 of the Transportation Act, totaling $26,980,000; but it still has a loan of $21,705,000 under Section 210.

The Erie retired a debt of $8,725,000 under Section 207 and one of $11,574,000 under Section 210. Smaller payments were made by a large number of roads.

Operating Factors in Locomotive Fuel Efficiency

By A. E. WARREN, General Manager, Central Region Canadian National Railway

Papers and Reports to International Railway Fuel Association

It may generally be conceded as true that no industry presents its management with such a diversity of involved problems as does railway operation. We might, for example, contend that transportation is paramount in railway organization, and yet on reflection it is extremely difficult, if not impossible, to enthrone any one of the various activities of a railway. Transportation cannot function without tracks, facilities, power and equipment, to say nothing of traffic, finance and accounting. The whole is dependent on each, and effectiveness suffers in the degree that the unit fails to function. But, in the highly complex and difficult operation of a railway, we can and do accentuate the importance of certain phases which, because of their special functions, their distinguishing characteristics, such as their relation in safety, economy and expedition to the general conduct of the operation, are proclaimed above others as desirable or necessary fields for concentration. Prominent among these is fuel, inseparable as it is from the vitality of railway operation, and this concentration on fuel economy has engaged and is today more than ever influencing the thought of the most talented mechanical and operating men, and, in degree, the men in the cab, all intent on securing greater economic efficiency. We all agree that fuel holds the same relative position to the locomotive that food does to the human body, therefore, as we take concern for the quality of the food we eat, so that we may secure the proper substances producing the maximum of vitality with the minimum of effort, so in the railway is the quality of fuel best suited to our motive power of first importance, to see that it is suitable and fit to enter the firebox or stomach of the locomotive and that its quality and quantity and distribution will effect such assimilation as will ensure the greatest vigor or tractive effort possible. Speaking for the Canadian National Railway, this quetsion of fuel supply is indeed one of our greatest problems, because it is, next to labor, one of the largest items of expense, and not only so, but it costs us about 90 per cent more per ton on the Central Region and 75 per cent more on the system than the average cost for class 1 roads of the United States. One of the factors is that we are obliged to pay 50 cents a ton customs duty on every ton of bituminous coal imported. It is true that other forms of energy are pressing for recognition, but at present coal is the chief source from which we can develop the energy required to conduct our transportation. Through some irony of nature, in all the 8,348 miles of railway comprising the Central Region alone of the Canadian National, serving all the important centers in Ontario and Quebec, there is not one coal mine. We have gold, silver, nickel and copper mines in what perhaps might be termed abundance, but not a single commercial coal seam in operation. Consequently all our coal supplies have to be drawn from far Eastern Canada and from our good neighbors to the south. The consumption therefore of 5,500,000 tons annually has a most definite and serious effect on our operating expenses. We have, however, succeeded in the last four years in reducing our pounds per passenger train car mile 9.5 per cent and pounds per 1,000 gross ton miles 15.5 per cent. The replacement, where practicable, of branch line steam passenger trains by oil-electric type self-propelled cars, has secured a fuel economy of approximately 50 per cent.

Purchase and Inspection of Fuel

The purchase of our fuel is under the immediate jurisdiction of our Fuel Department, subject, of course, to the chief executive, and that department distributes in the requisite quantities by rail and lake, or all-rail, from the various sources of supply. In the areas from which access is secured by water during the summer, it is necessary to store the coal in large stock piles at selected centers, from which supplies are taken after the close of navigation. This in turn involves many problems for the proper care of the fuel so stocked, so that the minimum deterioration will be secured. Even in the case of coal supplied by rail throughout the year, we find it advantageous, if not necessary, to carry substantial emergency stocks, because of our remoteness from the source of supply, and from conditions beyond our control. Great care has to be exercised in providing coal of suitable quality, having due regard to the type of locomotive (hand or stoker fired), length of run and conditions attending its operation. We have adopted the procedure of employing inspectors at the mines, with authority to accept or reject the coal there, and for this purpose we employ a small but efficient band of inspectors whose duty it is to examine and report on the quality of the fuel loaded for us at the various mines. The sizing and appearance of the coal being loaded is not the only check exercised, samples from the various mines are taken at frequent intervals, and the analysis closely studied and tabulated for immediate action, as well as consideration when making further purchases. The fuel is again subjected to a further scrutiny when received on our rails. The results we have secured justify this procedure, and complaints of unsatisfactory fuel are comparatively few. In the purchase of this fuel we, of course, endeavor to secure the most suitable fuel at the lowest price, having due regard to the mine cost, freight haul, stocking, reloading to cars for distribution, and chute handling. We provide where possible our own car equipment, which assists the regularity of supply and operation so essential to a satisfactory operation. This, of course, also requires close co-operation between our operating, mechanical and fuel departments, without which no satisfactory results can be secured.

The Modern Locomotive

Most of us realize that the steam locomotive of today, with all its modern fuel-saving devices and great tractive power, has developed into one of the highest examples of mechanical engineering. It performs its work under conditions which, at their best, are very severe, due to restrictions placed upon the designer by the necessity of keeping within certain limits of size controlled by the gauge of the rail, stress on bridges, and clearance of highways and overhead structures. It naturally follows that if we are to secure the best results from these superclass machines, they should be maintained in a high state of efficiency. To do this economically, we must have modern locomotive terminal facilities at the main locomotive houses; coaling stations and water spouts conveniently located, with sufficient run-around tracks so that switching and transfer locomotives requiring coal, or water only, may be handled without delay, or interference with main line locomotives requiring more attention. These main locomotive houses should have labor-saving equipment such as proper ashpits, washout and water filling system, modern wheel drop pits, moveable cranes for handling heavy locomotive parts, and motor-driven trucks to move material promptly. This does not mean that we should embark on a campaign for new locomotive houses, not at all; but when new buildings must, of necessity, be erected, these facilities naturally should go with them. In many cases we have found that extension of a locomotive house back wall will take care of the situation and permit of the installation of modern appliances for handling the locomotives when under repairs.

In this connection, our stores department has contributed to our efforts in speeding up shop output, by assuming full responsibility for all work pertaining to the receiving, storing and disbursing of material. This includes the successful operation of the delivery of material to employees in the shops by store employees on a systematic delivery schedule. This not only effected a reduction in payroll expense, since some of this work was performed by employees in the mechanical department, many of whom were paid higher rates than store labor, but has released skilled labor, permitting its employment on skilled work. Material requirements have been successfully met without causing delay, due principally to closer co-operation between users of material and the supply department.

At our large locomotive terminals, we have installed motor drive to our air compressors and put in motor-driven washout pumps. This has permitted us to close down the steam plant at those terminals during the summer, making a positive saving of fuel and labor cost.

These high power locomotives have a very heavy first cost, therefore, the management is equally interested with the mechanical and engineering departments in providing adequate locomotive house facilities to handle them without unnecessary delay and at a minimum cost. For every hour they are out of service their great earning power is lost to the operating department.

Train and Yard Operation

Our complex industrial and commercial activity of today demanding the maximum of service in the minimum of time; the modern trend of carrying less supplies and materials in stock; the perishable nature of a great many commodities, all demand an expedition in movement that means increased speed and consequent higher fuel consumption and decreased locomotive tonnage. There is perhaps no one feature of road operation more conducive to fuel economy than the establishment of and adherance to proper locomotive ratings. There are a great many factors to be considered in arriving at the most economical rating for each subdivision. The final objective is, of course, maximum ton miles per dollar and generally this coincides with the maximum load that can be handled over a subdivision at an average speed, allowing for all road delays, of 12½ miles an hour. Owing to the fact, however, that most of our freight is today moving on schedules demanding a higher average speed than 12½ miles an hour, it is not always possible to adhere to the ideal rating, and we are forced to lighten our trains below the most economical loading. The aim, however, should be the maximum loading within the economical limits consistent with the maintenance of schedules, and to make this a maximum, trains should be given as much time as consistently possible on the road, by reducing terminal time to a minimum. To stop and start a tonnage freight train consumes from 300 to 600 lb. of coal, depending upon the load and grade conditions, and an improved freight locomotive will burn from 7 to 10 lb. of coal a minute while standing. A great deal of attention should, therefore, be given to the elimination of stops and road delays, and all can and should help in this important feature. In order to secure exact road operating performance facts, and assign the power properly, we keep a dynamometer car busy obtaining economical operating information. We have a force of travelling firemen and road foremen of locomotives, an important portion of whose duties is to instruct firemen and locomotive men in the economical use of fuel.

The management can make a positive saving in fuel by providing funds, where density of traffic and the savings to be made will justify the expenditure, for installation of improved signals, interlocking plants and remote control switches at passing tracks. The use of the 19 order, where feasible, and the operating of trains on double track against the current of traffic, are two features which are being given a great deal of attention by transportation superintendents and dispatchers. The car department, by keeping the equipment in such condition as to reduce hotboxes and other delays due to equipment failures, are contributing factors in fuel economy.

Another problem, which can be studied with profitable results by all concerned in fuel economy, is the extension of locomotive runs. We have found that when locomotives are run through, a reduction of forces at the intermediate terminals can be made, dependent upon the nature of the terminal and the forces employed, saving in labor, cost of repairs due to the centralization of work, saving in hostlers, due to fewer dispatches. We are extending the practice as rapidly as the additional facilities necessary can be provided, always with the understanding that the saving to be made will more than offset the interest and maintenance of new facilities required. The dumping and lighting up of a modern locomotive requires approximately one ton of coal; this saving is effected on every locomotive run through an intermediate terminal. The results so far obtained indicate that the extended runs provide a more efficient performance at reduced cost, and effect a saving of locomotive power. We have found the saving in power due to extension of locomotive runs greatly assists in the elimination of obsolete, excessive coal-consuming locomotives.

Yards and terminals are responsible for the fuel consumed by yard locomotives as well as that consumed by road locomotives before leaving or after arrival at terminal. The importance of the fuel consumed by yard locomotives is apparent from the fact that 20.3 per cent of our total locomotive fuel in 1926 was chargeable to yard operation. Yard plants should be studied to insure that the movement of all cars is continuous in the direction in which the car is moving and that it receives the minimum number of handlings between arrival and departure. Leads should be arranged in such a manner that switching operations are not held up while long freight trains are entering or leaving the yard. Auxiliary tracks, such as repair tracks, scale tracks, caboose tracks, etc., should be conveniently arranged for their purpose. The greatest advantage possible should be taken of gravity; lead and ladder tracks built at a higher elevation than body tracks. Terminal air-testing plants are an important factor in avoiding delay, and should be installed wherever possible. Terminal detentions to road power are in the hands of yard forces, and should be avoided by having trains switched a sufficient length of time in advance of the hour ordered so as to allow the car department to complete inspection. Yardmasters and car foremen should co-operate so that repair tracks will be switched at the noon hour, thus avoiding interruption to the car repairmen during working hours. Incoming trains should be yarded promptly and road locomotives released immediately after arrival.

By co-ordination of the work of the various terminals on a division or district, much can be done to avoid unnecessary switching. A definite scheme of train marshalling, with a view to a minimum number of handlings of cars by switch locomotives between loading and unloading points, will not only cut down the total switching necessary, but will speed up the movements of trains through terminals.

Economies in Long Locomotive Runs

By T. H. Williams, Assistant General Manager, Southern Pacific System

In January, 1924, the Southern Pacific was operating six trains a day between Los Angeles, Cal., and El Paso, Tex., and two between Los Angeles and Tucson, Ariz., that is, four trains per day in each direction.

Prior to the time we started to run our engines through, it required 40 locomotives to handle the eight trains, which included sufficient power to handle the pool of runs and to take care of relief work and the shopping of the engines.

These 40 locomotives consisted of Mikado, Pacific, ten wheeler and Atlantic types, being assigned as follows: Between Los Angeles, Cal., and Yuma, Ariz., a distance of 252 miles, we used the Mikado type. On two of these trains we used the Mikado engine between Los Angeles and Indio, a distance of 130 miles, and at Indio these engines were relieved by Pacific type power, the latter engines making the run from Indio to Yuma, a distance of 122 miles. At Yuma the ten-wheel engines were used for the run to Tucson, Ariz., a distance of 251 miles. At Tucson Mikado engines were placed on the trains for the run from Tucson to Lordsburg, a distance of 164 miles. At Lordsburg Pacific and Atlantic type engines were placed on the trains for the run to El Paso, Texas, a distance of 148 miles.

Trains were handled in this way prior to the time we started to run locomotives through between Los Angeles and El Paso, providing for five sets of locomotives and making four changes at intermediate terminals in the 815-mile run.

In January, 1924, we placed in service 10 Mountain type engines to run through and discounted cutting engine in and out of trains at all of these district and division terminals. Later, as more of the mountain type engines were received, we filled the pool with a complete complement of this class of power.

Today we are running 10 passenger trains per day, five in each direction between Los Angeles and El Paso, and have 25 mountain type engines assigned to the through service. This is sufficient to take care of relief work and to provide for shopping.

For a long time we ran these engines without the protection of having an engine of this type at intermediate terminals to protect in case of engine failure, but recently we established the practice of changing one engine out at Tucson, Ariz., and one at Yuma, Arizona, on one westbound passenger train each day; this to give us an engine at these two points for protection in case of engine failure and to equalize the mileage made by the total engines employed in the pool.

To handle the 10 trains per day under the old method of operation of changing engines at district and divisional terminals, it would require 50 locomotives, while under our plan of running the engine through it requires 25 locomotives.

Since January, 1924, the date we started to run the engine through, we have constructed a new main line in Arizona from Wellton to Picacho, via Phoenix, which has added 44 miles to the run to El Paso and gives us a double track line between Wellton and Picacho.

We have also acquired the El Paso & Southwestern Railroad running from Tucson to El Paso, giving us a double track line between these two points and increasing our mileage via this route 29 miles in the total distance between El Paso and Los Angeles.

By the construction of the new line through Phoenix, the acquisition of the El Paso & Southwestern, and the scheduling of our trains over these new routes, we have increased the run of the Mountain type engines from 815 miles to 843 miles, 858 miles and 888 miles.

These engines after the run of 88 miles have an average layover at El Paso of 14½ hours and at Los Angeles, 26 hours. At both points we have modern shops.

These Mountain type engines, in the run of 88 miles, take fuel at four points en route, but the tender has sufficient fuel capacity to take oil only twice en route. The reason for taking fuel four times is to save the long haul of oil to distant points from the oil fields. These engines make long runs for water, the longest run being 160 miles from Aqua, Ariz., to Picacho, Ariz.

We now come to the question of economies in long locomotive runs, which is the subject on which I was invited to address you.

First let us show what has become of the locomotives formerly employed, particularly the excess number of locomotives required to perform the service when they were working on short runs. The Mikado engines are hauling heavy freight trains on our Salt Lake and Rio Grande divisions. The Pacific and Atlantic type engines have been re-assigned to valley territory where best fitted for the needs of our business.

Six months after we started to run our engines through over this 815 mile territory, we took off round house forces at the intermediate terminals to the extent of saving us $8,000 per month, or $96,000 per year. It takes no stretch of imagination to know that it requires man power to move engines to sand house, oil and water columns, and to put them across the turntable and into the roundhouse. We have saved all such roundhouse attention and handling at these intermediate terminals.

In engine house fuel, prior to the time we started to run the engines through, we consumed 66 barrels of oil per day, which at the price we were then paying for oil amounted to a saving of $2,692 per month, or in round figures—$32,000 per year.

We have made a substantial saving in cost per locomotive mile for classified repairs. The pool of 40 engines employed before we started the long locomotive runs averaged 76,943 miles per engine between shopping periods for classified repairs. Last year the pool of 25 Mountain type engines now running through made an average of 116,827 miles per engine between shopping periods for classified repairs, an increase of 50 per cent. Some of these engines are making over 14,000 miles per month.

The cost per locomotive mile for classified repairs on the pool of engines employed in the service before we started to run the engines through was 9.203 cents per locomotive mile, a decrease of 16 per cent. This decrease is due in part to less abuse of the Mountain type engine on account of their adaptability to work required over this territory as compared with former type of locomotive used.

The greatest factor of decreased cost per locomotive mile for classified repairs in my judgment is the saving of the metal of the boiler. We now cool the engine down once where we formerly cooled the engine four times.

In capital investment in this one pool of engines we have saved $571,045 and with interest at 6 per cent and depreciation 4½ per cent, this gives us an annual savings of $59,960 per year.

Diesel Locomotive Performance

In the issue of Railway and Locomotive Engineering for May there appeared an abstract from the Committee's report on Diesel engines to the International Fuel Association. The following is a further section of the report dealing with Diesel locomotive performance.

Several of the Diesel oil-electric locomotives in this country were placed in service late in 1925 or early in 1926, and it was thought that by sending out a questionnaire to the companies operating them considerable information could be obtained as to the cost of operation and maintenance and the kind of service rendered. This was done, and replies were received from all but two of the companies using these locomotives.

Typical examples of the valuable information given in reply to the questionnaires follow:

Service Record of One 60-Ton, 300 H.P. Oil-Electric Locomotive Reported by Road "A"

Class of Service: Switching in small delivery yard
Placed in service: January 1st, 1926
Total Mileage in 1926: 21774
Cost of operation, not including wages of crew, for year 1926:

Fuel	$ 769.00
Lubrication	113.00
Supplies	98.00
Cleaning and Housing	1,489.00
Repairs	1,882.00
Depreciation at 12% and Interest	7,500.00
Average Total Cost per car handled	3.22
Average number of cars handled per day during 1926	26½

This represents the actual cars brought into yard per day and does not indicate the number of times each car is handled.

Service Record of One 60-Ton, 300 H.P. Oil-Electric Locomotive Reported by Road "B"

Kind of Service: Hauling log and work trains, and switching.

Hours Operated: From September 23rd, the date the engine was put in service, to the end of February, the locomotive worked 140 twelve-hour shifts; in for repairs forty days, tied up Sundays, Holidays, and no work sixteen days. Cost of fuel oil, lubrication oil, supplies, etc., October to February inclusive, $1,796.45.

Service Record of 60-Ton, 300 H.P. Oil-Electric Locomotive Compared with a Steam Locomotive as Reported by One Road

	Oil-Electric Loco. Aug.-Sept.-Oct., 1926	Cost Unit	Cost Total	Steam Locomotive Apr.-May-June, 1926	Cost Unit	Cost Total
No. days operation	74			78		
Hrs. loco. service	608			644.5		
Fuel consuming hrs.	518			644.5		
K.W. hours	9082					
Fuel						
Fuel oil, gals.	1620	.0575	93.15			
Diesel eng. oil, gals.	45.5	.54	24.57			
Gasoline, gals.	1	.21	.21			
Valve oil				15	.525	7.88
Coal, tons				100.1	8.89	889.89
Water—100 cu. ft.				293.40	.10	29.34
Eng. oil, gals.	15	.2825	4.24	15	.2825	4.24
Other Supplies						
Sand, tons	3	1.50	4.50	3	1.50	4.50
Waste, lbs.	75	.0975	7.49	30	.0975	2.93
Grease, lbs.	15	.135	2.03			
Maintenance and Inspection						
Electrical			122.42			
Mechanical			205.10			220.13
Locomotive Repairs			315.00			300.00
Wages						
Engineer			524.83			558.98
Fireman						439.20
Trainmen			987.91			982.71
Watchman			225.00			
Hostler						393.00
No. floats handled	182			198		
No. cars handled	2636			2677		
Tons handled in and out	36067			47856		
TOTAL			$2,516.45			$3,832.80
Savings						
Not incl. int. & deprec.			1,316.35			
Percent			34.3%			
Interest on investment	$61,128	6%	916.92	$16,000	6%	240.00
Depreciation	61,128	5%	764.10	16,000	5%	200.00
Total			4,197.47			4,272.80
Saving						
Incl. int. & depre.			75.33			
% oil over steam			1.76%			
K.W. per ton handled	.249					
Cost per K.W. hour			.462			
Cost per ton handled			.116			.0893
Cost per car handled			1.592			1.596

Cost of Maintenance: $2,543.56.

Kilowatt-hours for October, 31,550

Cost of fuel, oil, etc., $584.31.

Cost per Kilowatt-hour, $0.0185.

Kilowatt-hours generated for November, 27,710.

Cost of fuel, oils, etc., $404.28.

Cost per Kilowatt-hour, $.0146.

Comparison is made with a steam locomotive of approximately the same rating, with superheater and feed water heater, and using oil for fuel:

	Diesel	Steam
Hours run	44½	30¼
Ten miles	90,531	124,956
Total cost	188.62	320.18
Cost per hour	4.26	10.58
Cost per ton miles	.00208	0.00256

The total cost item includes fuel, train and engine crews' wages. The service is main line train work, hauling log trains 13.5 to 17.5 miles, more than half of which is over a long steep grade, averaging 1.85 to 2%. The Diesel locomtive will do the same amount of work as the steam locomotive at considerably less operating expense, and will burn from 120 to 160 gallons of oil per day, while the steam locomotive will burn 600 to 800 gallons per day. In most cases the Diesel locomotive is better adapted to the service on the sharp curves and grades where low speed is necessary. A good comparison of the two locomotives is obtained on switching jobs. The Diesel locomotive has recently been in switching service averaging five hours per day, and using 35 gallons of oil per day. The steam locomotive in the same service burns from 75 to 100 gallons per day.

Comparison of Operation with Steam Locomotives

In this particular yard, the oil-electric locomotive, due to its construction, permits of a better operation than the steam locomotive formerly used. The record is given in the tabulation on the preceding page.

This locomotive has been in service only a little over a year, but during that time the operation of it has been satisfactory, with the exception of two failures. It was out of service for a period of 12 days during March and April, 1926, on account of No. 6 wrist pin bearing completely burned out, and for a period of 27 days in August and September, 1926, on account of commutator burned out. In addition to the above, there have been delays in the yard for various reasons, but only for a very short period of time.

It has been indicated that for every dollar expended for fuel oil for the Diesel engine $.233 was spent for lubrication. The operating costs reported now indicate that the cost for lubricating oil was about $.248 for every dollar expended for fuel oil.

Some means of filtering the lubricating oil should be provided on the locomotives to purify the oil and thus make it possible to extend the time between changes. This should materially reduce the cost of lubrication.

The operating, maintenance and repair costs as now reported cover a wide range due to the extreme variation in operating conditions. Some of the locomotives have only been in service a short time and have had practically no cost for repairs charged against them.

Rotating Apparatus on the Virginian Locomotives

By J. O. Sherrard, Motor Engineer, Westinghouse Electric & Mfg. Company

Two of the principal advantages of an electric locomotive are: first, the large percentage of time which the locomotive is available for service, and second, the mileage obtained per locomotive from one overhaul period to the next. These advantages naturally result in low maintenance cost per locomotive mile. On the rotating apparatus of the heavy freight locomotives of the Virginian Railway these two advantages are gained by rugged construction and easy access to those parts which require maintenance.

At present the Virginian road and pusher locomotive are made up of three units or cabs connected by drawbars, although the control is so arranged that as many as four units may be operated in multiple by one engineman. Power is taken from a single-phase, 25-cycle, 11000-volt trolley circuit through an oil-insulated transformer in each unit where it is reduced to voltages required for the different apparatus. The available voltages on the secondary of the transformer range from 92 to 1500.

The phase converter is self-ventilated with a continuous capacity of 2000 kva. and runs at 750 r.p.m. It is wound like a two-phase induction motor with a wound rotor and when up to speed it runs single phase. Voltage is generated in the other phase so that two-phase power is made available. With a Scott connection to the main transformer three-phase power is furnished for the traction motors. A low voltage tap on the phase converter, in conjunction with suitable taps on the transformer, supplies power for the auxiliary induction motors.

The phase converter rotor has a distributed winding and the slots are skewed to give a voltage wave free from ripples. The winding is so arranged that it performs the double function of exciting and damping. This eliminates the necessity of a cage winding for damping and simplifies the rotor construction.

The method of supplying excitation current through leads in the shaft has already been described.

Two-piece ring oiled bearings are used and the construction is such that the bearing caps may be removed and the bearings changed without removing the bearing brackets. The bearings can easily be reached for oiling from the side aisle of the locomotive. Each bearing consumes about one quart of oil per year. A drain is located in the bottom of each housing for renewing the oil and flushing the bearing.

The system of ventilation is radial and the exhaust air is carried outside the locomotive by ducts.

The Phase Converter Starting Motor

After the locomotive air reservoirs have been pumped up, the electro-pneumatic switch for starting the phase converter may be closed. This switch applies power to the single-phase series motor which is used to start the phase converter and bring it up to speed. Once the phase converter is up to speed it will continue to run alone on the line. The starting motor is then automatically changed to a direct current generator for supplying excitation to the phase converter rotor winding. With this field excitation the phase converter operates with the same power factor advantages as a synchronous motor.

Referring to the phase converter and starting motor -The armature of the starting motor is mounted directly on the phase converter shaft and the stator is bolted to the phase converter frame. This combined construction eliminates the necessity of any coupling device and consequently the labor of aligning the two machines when they are installed. The space occupied is a minimum since only two bearings are used.

The starting motor brushholder support is open so that brushes can be inspected or changed in the least possible time. The phase converter brushholders, which are used to carry the excitation current to the phase converter rotor, through two collector rings, are also carried on this brushholder support. Leads to the phase converter rotor winding are brought to the outside through a hollow shaft. This makes it possible to inspect or change the collector rings, brushes and brushholders without removing any other part of the phase converter.

The Traction Motors

The wheel arrangement of each unit is 2-8-2 with a jackshaft at either end located between the end driving axle and the pony truck. Each jack-shaft is driven by a motor mounted directly above it. The drive is through pinions on both ends of the motor shaft to flexible gears on the jack-shaft. The jack-shaft in turn is connected to the drivers by side rods.

One of these traction motors may be described. It is a three-phase, wound rotor, induction motor with a stator winding arranged for speeds of 375 and 750 r.p.m. These speeds correspond to locomotive speeds of 14 and 28 miles per hour respectively. To gain these speeds the stator connections are changed from an eight pole winding at 14 m.p.h. to a 4 pole winding at 28 m.p.h. This change is accomplished with only six leads coming from the stator winding. The rotor winding is so arranged that it is not necessary to change from one pole combination to the other. This makes it possible to omit a rotor pole changing switch.

The motor frames and bearings are supported by rectangular cross ties, which are bolted to the locomotive side frames. There are two horizontal seats and one vertical face, which are a part of the cross ties and extend the full distance between side frames. Each motor frame is bolted to the horizontal seats and against the vertical face thereby holding it rigid in all directions. Shims are used to get the proper air gap between stator and rotor. The bearings are held in place by caps which are bolted to the cross ties above each side frame.

This split bearing housing construction makes it possible to use two piece motor bearings which can be renewed without pulling motor pinions or collectors. Lateral can also be easily taken up, because the rotor end thrust is taken on the inner end of the motor bearings, which can be shifted in the housings. The bearing shells are flanged so that liners to compensate for lateral wear can be inserted between this flange and the locomotive side frame. The bearings are ring oiled from oil wells in the motor cross ties. Each oil well has a capacity of two gallons.

Previous practice on this type of locomotive has involved the use of a solid bearing housing which has necessitated the use of tapered bearing shells inserted in the housings from the outside. This made it necessary to take the end thrust between the outer end of the motor bearings and the pinions. To adjust lateral, pinions and collectors had to be pulled.

When starting a locomotive, resistance in the form of a liquid rheostat is inserted in the rotor circuit. This resistance is cut out a step at a time as the locomotive is accelerated. When the locomotive is up to speed the rotors are short circuited. Connection is made to the rotor winding through collectors on each end of the motor shaft. Leads run from each collector through the motor shaft to the winding. This construction puts the collectors and brushholders outside of the bearings and pinions and makes these parts accessible for inspection through trap doors in the locomotive side aisles. Collectors can be removed without taking the motor from the locomotive.

Each traction motor is force ventilated by a blower mounted on a control rack above the motor. Air is blown into each end of the motor through sheet steel end bells and the exhaust air is discharged radially to ducts which carry it outside the locomotive.

The Air Compressor Motor

There are two motors on each unit which can utilize the single-phase voltage directly for starting. One of these is the motor which drives the air compressor and the other is the phase-converter starting motor. A doubly-fed single-phase motor which runs 1200 r.p.m. is used to drive the air compressor, which is directly connected to the motor through a flexible coupling. The circuit to the motor is so arranged that the motor starts when the circuit breaker is closed and is shut down as soon as the main reservoir pressure has reached 130 lb. The motor is cut in again when the pressure drops to 110 lb. Each compressor has a displacement of 150 cubic feet per minute and with all three cut in, a dead locomotive can be pumped up in two and one half minutes. However, only two of the three available compressors on a locomotive are used at one time.

All the auxiliary motors, other than the compressor motor, are cage wound induction motors. Four of these in each unit have interchangeable parts. These are the two traction motor blower motors, the pump motor, which circulates the electrolyte in the liquid rheostat, and the combined pump and blower motor, which circulates the main transformer oil and furnishes air for both the oil cooling radiator and the electrolyte cooling tower. All parts of these four motors are the same except the shafts and the pump end brackets. This reduces the carrying of spare parts for these motors to a minimum.

Notes on Domestic Railroads

Locomotives

The New York Central Railroad has ordered 11 locomotive tenders from the American Locomotive Company. One of these tenders will have a capacity of 12,500, and 10 will have a capacity of 15,000 gal.

The Manila Railroad has ordered 3 three-cylinder Pacific type locomotives from the Baldwin Locomotive Works.

The Missouri Pacific Railroad is inquiring for 5 Mikado type locomotives.

The American Railroad of Porto Rica has ordered one consolidation type locomotive from the Baldwin Locomotive Works.

The Denver & Rio Grande Western Railroad is inquiring for four 2-8-8-2 Mallet type locomotives.

The Pennsylvania Railroad has ordered 25 K-4-S type locomotives from its Altoona Shops at Altoona, Pa.

The Johnstown & Stony Creek Railroad has ordered one six-wheel switching locomotive from the Baldwin Locomotive Works.

Hiram Ricker & Son, Poland, Springs, Maine, has ordered one six-wheel switching locomotive from the American Locomotive Company.

The Inquique Pintados is inquiring through the locomotive builders for 5 Mikado type locomotives

The Great Northern Railway is inquiring for one snowplow

The State Belt Railway of San Francisco is inquiring for one six-wheel switching locomotive from the American Locomotive Company.

The Amtorg Trading Corporation, New York, N. Y., has ordered 3 saddle tank locomotives from the American Locomotive Company.

The Lehigh & New England Railroad has ordered 2 Decapod locomotives and 6 switching locomotives from the Baldwin Locomotive Works.

The Alberta Great Waterways Railway are inquiring for two consolidation type locomotives.

The Chesapeake & Ohio Railway is inquiring for 30 eight-wheel switching type locomotives.

Passenger Cars

The Chesapeake & Ohio is inquiring for three all steel, 70-ft. mail and express cars.

The Atchison, Topeka & Santa Fe Railway has ordered 10 dining cars, 8 buffet library cars, and 15 baggage and mail cars from the Pullman Car & Manufacturing Corporation.

The Illinois Central Railroad has ordered 10 baggage cars from the St. Louis Car Company.

The New York, New Haven & Hartford Railroad is inquiring for 15 steel underframes for baggage cars.

The Gulf, Mobile & Northern Railroad is inquiring for one business car.

The Norfolk & Western Railway is now inquiring for 25 mail storage cars.

The New York Central Railroad has ordered 4 business cars from the Pullman Car & Manufacturing Corporation.

The Union Pacific Railroad has ordered one combination mail, baggage and passenger, gas-electric rail motor car from the Electro-Motive Company.

The Atchison, Topeka & Santa Fe Railway has ordered one combination passenger and baggage, gas-electric rail motor car from the J. G. Brill Company, Philadelphia, Pa.

The American Railway Company of Porto Rica is inquiring for 2 passenger coaches.

The Long Island Railroad has ordered one combination passenger and baggage rail motor car from the J. G. Brill Company, Philadelphia, Pa.

The Chicago, North Shore & Milwaukee Railroad is inquiring for 20 steel electric interurban cars.

The Erie Railroad is inquiring for 25 all steel baggage and express cars.

The Reading Company has ordered 10 baggage cars from the American Car & Foundry Company and 5 from the Bethlehem Steel Company.

The Seaboard Air Line Railway has ordered 9 gas-electric rail motor cars and 10 trailer cars from the American Car & Foundry Company and J. G. Brill Company, Philadelphia, Pa.

The Illinois Central Railroad has ordered 6 baggage and mail cars from the American Car & Foundry Company.

The Northern Pacific Railway has ordered 10 steel underframes for baggage cars from the Siems-Stembel Company.

The Toronto, Hamilton & Buffalo Railway has ordered one combination passenger and baggage gas-electric rail motor car from the Electro-Motive Company.

The Lehigh & New England Railroad has ordered one passenger gas-electric rail motor car from the J. G. Brill Company, Philadelphia, Pa.

The Norfolk & Western Railway has ordered 25 steel storage mail cars from the Bethlehem Steel Company.

The Atchison, Topeka & Santa Fe Railway has ordered 2 passenger and baggage, gas-electric rail motor cars from the Electrio-Motive Company.

Freight Cars

The Fort Worth & Denver City Railway has ordered two all-steel automatic air dump cars from the Western Wheeled Scraper Company

The Duluth, Missabe & Northern Railway has ordered 125 ore cars of 70 tons capacity from the General American Car and 125 from the Standard Steel Car Company.

The Lehigh & New England Railroad has ordered 200 all steel box cars of 50 tons capacity from the Pressed Steel Car Company.

The Chicago & North Western Railway is inquiring for 25 caboose cars underframes.

The Carnegie Steel Company has given a contract for making repairs to 150 steel hopper cars to the Pressed Steel Car Company.

The Chicago & Illinois Midland Railway is inquiring for 200 steel underframe box cars of 40 tons capacity.

The Anglo-Mexican Petroleum Company is inquiring for 15 gondola cars of 40 tons capacity and 15 box cars.

The Phillips Petroleum Company, is inquiring for 10 tank cars.

The Duluth, Missabe & Northern Railway is inquiring for 250 ore cars of 70 tons capacity.

The Utah Railway has ordered one caboose car from the Mount Vernon Car Manufacturing Company.

The Pacific Great Eastern Railway has ordered 10 air dump cars from the Western Wheeled Scraper Company.

The Georgia & Florida Railway has ordered 60 box cars from the American Car & Foundry Company.

The New York Central Railroad has ordered 10 special flat cars from the Standard Steel Car Company.

The Litchfield & Madison Railway has ordered 100 composite drop bottom gondola car bodies and 147 solid bottom gondola car bodies from the American Car & Foundry Company.

The United Fruit Company is inquiring for 25 flat cars, 3 tank cars and 75 box cars.

The Chicago, Rock Island & Pacific Railway is inquiring for 100 composite gondola car bodies of 50 tons capacity.

The New Jersey, India & Illinois Railroad has ordered 100 box cars of 40 tons capacity from the American Car & Foundry Company.

The Norfolk & Western Railway is in the market for two wrecking cars of 200 tons' capacity and is arranging to rebuild 200 steel coal cars of 90 tons' capacity at its Roanoke shop.

The Great Northern Railway has ordered 250 general service gondola cars of 70 tons' capacity, from the Pressed Steel Car Company.

The Chesapeake & Ohio Railway is inquiring for 112 steel underframe caboose cars.

The Chicago & North Western Railway has ordered 500 box cars from the Standard Steel Car Company and 500 from the General American Car Company.

The Sunlight Coal Company, Chicago, Ill., has ordered 10 air dump cars of 30 cu. yd. capacity from the Koppel Industrial Car & Equipment Company.

Buildings and Structures

The Chicago, Rock Island & Pacific Railway has awarded a contract to Joseph E. Nelson & Sons, Chicago, Ill., for the construction of a water treating plant at Kansas City, Kan.

The New York Central Railroad closed bids for work on new office building at 46th street and Depew place, New York. The new office building will be 38 stories in height with a tower, and is to cost approximately $10,000,000.

The Pennsylvania Railroad will build a steel cab ramp at its New York City Terminal. The ramp will run to about 350 tons, which have been ordered from the American Bridge

The Panhandle & Santa Fe Railway plans the construction from White Deer to a point 21 miles northwest in Carson and Hutchinson counties, Texas.

The Southern Railway plans to build a 400-ton steel bridge over Coosa River, in Alabama.

The Gulf & Ship Island Railroad has awarded a contract for the construction of cinder and sand handling facilities at Mendenhall, Miss. This project involves the construction of sand bins, a sand dryer and compresser house and cinder pits.

The Northern Pacific Railway plans the construction of a one-story brick and concrete power plant, with outside dimensions of 50 ft. by 100 ft. at Mandan, So. Dak. This plant will cost approximately $140,000. The company also plans the rebuilding of 14 stalls of the roundhouse at Glendive, Mont.

The New York Central Railroad has awarded a contract to Joseph E. Nelson & Sons, Chicago, Ill., for the construction of a brick and concrete interlocking tower at Gibson, Ind., to cost approximately $12,000.

The New York, Westchester & Boston Railway has awarded a contract to D. P. Robinson & Company, of New York, for double tracking its line from Harrison to Rye, New York. The line is to be all electric and work is to be completed within a year.

The Missouri-Kansas-Texas Railroad plans the construction of a one-story reinforced concrete pumping house and oil storage tanks at Parsons, Kan., at a cost of $45,000.

The Missouri Pacific Railroad plans for the construction of a water treating plant at Hermann, Mo., to cost approximately $30,000.

The New York Central Railroad has awarded a contract to the Walsh Construction Company, Davenport, Iowa, for the Construction of a 31 stall roundhouse at Harmon, New York, to cost approximately $470,000. This road also plans to build a 250-ton steel bridge at East Creek, New York.

The Chicago, Rock Island & Pacific Railway plans the remodeling of its freight station at Iowa City, Iowa.

The Atchison, Topeka & Santa Fe Railway has awarded a contract to C. A. Fellows, Los Angeles, for the construction of buildings ni connection with the enlargement of the engine terminal at Emporia, Kans. The structures included a 50 stall concrete and brick roundhouse and one-story apprentice school a two-story locker building and one-story office building and power house.

The Central Railroad of New Jersey plans the construction of a six-stall roundhouse at Bethlehem, Pa.

The Mississippi River & Bonne Terre Railway has awarded a contract for the construction of a 200 ton reinforced concrete automatic electric conveyor type coaling station at Bonne Terre, Mo.

The Chicago & North Western plans the remodeling of a boiler house at the Chicago avenue terminal, Chicago, Ill., at an approximate cost of $12,000. This company also plans the construction of a two-stall enginehouse at Linwood, Nebr.

The Chicago, Springfield & St. Louis Railroad plans the construction of a six-stall roundhouse at Springfield, Ill., with company forces. Also plan the rehabilitation of the roundhouse and shops at Jacksonville, Ill.

The Missouri Pacific Railroad has awarded a contract to the Humes-Deal Construction Company, St. Louis, Mo., for the construction of the walls, reinforced concrete floors and exterior terra cotta trim of the 22 story general office building at St. Louis, Mo.

The New York, New Haven & Hartford Railroad has awarded a contract to Henry R. Kent & Company, New Jersey, for the construction of a central boiler plant at South Boston, Mass., to cost approximately $500,000.

The Southern Railroad has awarded a contract to J. P. Pettyjohn & Company, Lynchburg, Va., for the construction of an office building at Danville, Va., to cost approximately $35,000.

The Chicago, Rock Island & Pacific.—A contract for the construction of locomotive repair shop facilities, including a one-story machine shop addition, at Silvis, Ill., at a cost of about $125,000, has been awarded to the T. S. Leake Construction Company.

The Boston & Albany Railroad has awarded a contract to the Company.

J. F. Fitzgerald Construction Company of Boston, Mass., for the erection of a boiler house at Worcester, Mass.

The Baltimore & Ohio Railroad has awarded a contract for water facilities at Glenwood, Pa., to cost $26,000. Another contract has been awarded for the construction of water treating plants at Cuyahoga Falls, Akron, Junction and Warwick, O., at a cost of $42,000.

The Pennsylvania Railroad has awarded a contract to the Belmont Iron Works of Philadelphia, Pa., for work on substation for electrification at Philadelphia and Wilmington divisions which will cost $89,000.

Supply Trade Notes

W. B. Murphy, vice-president and chief engineer of the **Miller Train Control Corporation** has been appointed also sales engineer of the company.

Burton L. Delack, assistant manager of the Schenectady works of the **General Electric Company** since December 1, 1926, has been appointed **acting manager, effective July 1**, according to an announcement by vice president **C. C. Chesney. Mr. Delack** fills the vacancy caused by the promotion of **C. E. Eveleth**, elected a vice president June 1 of this year. **Edward A. Wagner**, formerly of the Fort Wayne works but since July 1, 1926, managing engineer in charge of all distribution transformers, with headquarters in Pittsfield, has been made acting manager of the Pittsfield works, succeeding **Mr. Chesney**, who has been a vice president in charge of manufacturing since the retirement of **F. C. Pratt** and **Giuseppe Faccioli**, works engineer of the Pittsfield works, has been appointed associate manager and works engineer of the Pittsfield works, Mr. Chesney announced. These appointments are also effective July 1.

The Massachusetts Mohair Plush Company has removed its Boston Office from 200 Devonshire street, to the Chamber of Commerce building, 80 Federal street, Boston Mass.

J. P. Graver has resigned as president of the **Graver Corporation**, East Chicago, Ind., but remains as second vice president. **W. F. Graver**, vice president and treasurer has been elected president and treasurer, **K. W. Bartlett**, general manager, has been elected third vice-president and **A. E. Lucius** of **Lucius, Buehler & Lucius**, Chicago, Ill., legal representatives, has been appointed assistant secretary. **P. S. Graver** remains as first vice president in charge of sales and **H. S. Graver** remains as secretary.

The Graybar Electric Company, New York, has opened a new distributing house at 1529-31 First avenue, North, Birmingham, Ala. The building has two floors providing about 18,000 sq. ft. of floor space.

Henry S. Day, manager of the transportation division, **Westinghouse Electric & Manufacturing Company**, has been elected by the **United Electric Railways**, Providence, as superintendent of equipment. For the past five years he has had charge of all Westinghouse transportation activities in New England.

Mr. Day has had 25 years' **experience in contact with direct** maintenance of electric railway equipment, starting his career as a road engineer in the New York territory of the Westinghouse Company. For five years he was in charge of maintenance and inspection of electric motive power for the New York, New Haven, & Hartford Railroad and for three years he was connected with Sanderson & Potter of New York, engaged in valuation and appraisal of electric railway properties. With the outbreak of the World War, he went overseas as captain of engineers, following which he took a position with the Kansas City Railways, Kansas City, Mo., as equipment engineer in charge of the mechanical department. In this capacity he succeeded in reducing the expenses of the department to the extent of several hundred thousand dollars a year.

He returned to Westinghouse in 1923 as special representative in the railway department. In this capacity he was engaged in some studies of traction problems in Boston when he was appointed Manager of the Transportation Division, in the Boston Office of the Westinghouse Company.

The Hyman-Michaels Company, Chicago, has appointed the **Hofius Steel & Equipment Company**, Seattle, Wash., its representative in Washington and the Northwestern territory.

L. C. Hensel formerly sales representative in Chicago district for **Edison Storage Battery Company**, has been appointed sales engineer of the **Gould Car Lighting Corporation**, with headquarters at Chicago, Ill.

J. F. Shouse & Company, Louisville, Ky., has been appointed sales representative of the **Whiting Corporation**, for the state of Kentucky and the southern part of Indiana.

Theodore F. Mersels has been elected president of the **Johns Manville Corporation** to succeed **H. E. Manville**, who has been elected chairman of the board.

Gordon L. Edwards, has been elected treasurer of the **United States Steel Corporation** with headquarters at New York.

Laurence R. Wilder has resigned as president of the **American Brown Boveri Electric Corporation.**

E. W. Thomas, Jr., has been appointed representative in Chicago territory of the **Reading Iron Company**, Reading, Pa.

C. H. Thomas has been made manager of the Chicago office of the **Falk Corporation**, Milwaukee, at 122 S. State street, Chicago, Ill.

Earle M. Harshbarger, formerly of the **F. S. Bowser & Company**, has become associated with **S. K. F. Industries, Inc.**, where he will handle railroad and engineering sales in the Pittsburgh district. **M. S. McNay,** formerly sales manager of the **Bock Bearing Company, Toledo, Ohio, has been appointed western railway sales representative, with headquarters at 1140 West Washington boulevard, Chicago, Ill.**

George Thomas, has been appointed treasurer of the **Lukens Steel Company**, Coatesville, Pa.

The Industrial Works, Bay City, Mich., has closed its district office at Tampa, Fla. The district office at Atlanta, Ga., in the Hurt building will in the future handle all the business of Florida, Alabama, Georgia, North Carolina, South Carolina and the eastern portion of Tennessee.

A. L. Bliss, district sales manager of the **Buda Company** at Jacksonville, Fla., has been transferred to Atlanta, Ga.

Paul D. Cravath, for 30 years general counsel, was elected temporary chairman of the board of directors of the **Westinghouse Electric & Manufacturing Company** at a meeting of directors held July 6 in New York City. The board adopted a resolution instructing the executive committee to nominate a permanent chairman. It was stated on behalf of the committee that they had no one at present in view for this office. The only addition made to the board of directors was the selection of **W. L. Mellon** of Pittsburgh.

The **National Bearing Metals Corporation** has been formed, incorporated under the Laws of New York State, with offices at St. Louis, and New York, through the merger of **Bronze Metal Company**, New York, **More-Jones Brass & Metal Company**, St. Louis, and **Keystone Bronze Company**, Pittsburgh.

The past few months, **Bronze Metal Company** has acquired the business and properties of **Brady Brass Company, Southern Brass Works**, and **Damascus Bronze Company**, all of which now will be operated by, and under the name of **National Bearing Metals Corporation**, with plants located at the following points: St. Louis, Pittsburgh, Meadville, Jersey City, and Portsmouth.

The management of the new corporation will include **Alexander Turner**, chairman of the board, **John B. Strauch**, president, **Thomas H. Wright**, vice-president, **Arthur N. Dugan**, vice-president, **S. W. Crawford**, vice-president, **W. K. Frank**, vice-president, **A. Y. Evins**, vice-president, **R. S. Herman**, vice-president, **Frank H. Senn**, secretary and assistant treasurer, and **J. A. Neuwirth**, treasurer and assistant secretary. The St. Louis office will be at 4930 Manchester avenue, and the New York office at 30 Church street. The **National Bearing Metals Corporation** will specialize in the manufacture of railroad engine and car bearings, bronze and brass castings, motor axle and armature bearings, trolley wheels, babbitt metal, etc.

William M. Flook, chairman of the executive committee of the **American Brown Boveri Electric Corporation**, New York, has been elected chairman of the board of directors.

The Gulf States Steel Company, Birmingham, Ala., plan to expend about $3,000,000 on its plant and furnaces.

R. W. Patterson has been made manager of the Dallas, Tex., office of the **North American Car Mfg. Corporation.**

The Ingersoll-Rand Company has opened a branch office at 236 High St., Newark, New Jersey. In order to provide better sales and service facilities for its customers in northern New Jersey and certain adjacent counties of New York State, **F. K. Armstrong**, formerly connected with the Company's New York sales branch, has been appointed manager.

Items of Personal Interest

E. H. Carlson has been appointed master mechanic of the Northern Pacific Railway with headquarters at Livingston, Mont., succeeding **R. P. Blake**, transferred. **Ralph Hammond** has been appointed assistant master mechanic with headquarters at Staples, Minn.

H. W. Yates has been appointed master mechanic of the Rio Grande, Micolithic & Northern Railroad with headquarters at Van Horn, Texas.

W. C. Beck, assistant superintendent on the Quebec district of the Canadian Pacific Railway with headquarters at Ottawa, Ont., has been transferred to the Brownsville division of the New Brunswick district, with headquarters at Brownsville Junction, Me.

Robert E. Massa has been appointed car foreman of the Sante Fe System with headquarters at San Diego, Calif.

J. R. Vance, mechanical inspector of the Gulf Coast Lines, with headquarters at Houston, Texas, has been appointed to chief mechanical inspector of the Gulf Coast Lines and the International Great Northern Railroad with the same headquarters.

C. F. Morrett has been appointed supervisor of Locomotive operation of the Erie Railroad and **G. E. Lund,** assistant supervisor of locomotive operation, with headquarters at Huntington, Ind.
of the Northern Pacific Railway with headquarters at Livingston, Mont., has been transferred to the St. Paul division, with headquarters at St. Paul, Minn., succeeding **J. B. Neish.**

J. E. Carroll has been appointed tool supervisor of the Chesapeake & Ohio Railway with headquarters at Huntington, W. Va., succeeding **M. Branch** transferred.

Robert P. Blake, master mechanic of the Montana division

J. W. Skaggs, acting superintendent of terminals of the St. Louis-San Francisco with headquarters at Tulsa, Okla., has been appointed to superintendent of terminal with headquarters at Birmingham, Ala., succeeding **O. L. Young.**

J. L. Butler, master mechanic of the Illinois division of the Missouri Pacific Railroad jurisdiction has been extended to cover the Missouri division with headquarters at Poplar Bluff, Mo.

W. A. Curley, master mechanic of the Missouri division, with headquarters at Poplar Bluff, has been transferred to the Little Rock division, with headquarters at McGehee, Ark. **J. M. Whalen,** master mechanic at St. Louis, Mo., jurisdiction has been extended to cover the entire St. Louis terminal. **W. B. Shea,** general car inspector at Kansas City, Mo., has been appointed superintendent of shops with headquarters at DeSoto, Mo.

Samuel Wood has been appointed foreman of the air brake department of the Southern Pacific Company with headquarters at Sacramento, Calif.

A. H. Ehlers has been appointed superintendent of the Copper Ridge Railroad with headquarters at Houghton, Mich.

W. C. Higginbottom, has been promoted to general superintendent of transportation of the Western region of the Pennsylvania Railroad with headquarters at Chicago.

Walter Gould has been appointed car foreman of the Union Pacific Railroad with headquarters at Denver, Colo., and **J. H. Myers** assistant foreman with the same headquarters.

Paul W. Tillisch, chief clerk to the general superintendent of the Great Northern Railway with headquarters at Spokane, Wash., has been appointed to transportation inspector with the same headquarters.

J. J. Napier, superintendent of the Central region of the Canadian National Railways with headquarters at Capreol, Ont., has been transferred to Western region with headquarters at Brandon, Man., succeeding **G. A. Cunliffe.**

A. R. Pelnar has been appointed assistant to the general manager of the Chicago & North Western Railway with headquarters at Chicago, Ill.

C. H. Sauls, superintendent of the Virginia division of the Seaboard Air Line Railway with headquarters at Raleigh, N. C., has been transferred to the North Carolina division with headquarters at Hamlet, N. C.

J. M. Raine has been appointed assistant superintendent of the Chesapeake & Ohio Railway with headquarters at Rainelle, West Va.

E. D. Hanes, superintendent of the coal terminal of the Virginia Railway with headquarters at Sewalls Point, Va., has been appointed acting superintendent of the New River division with headquarters at Princeton, West Va.

C. W. Brown has been appointed general superintendent of the Lehigh & New England Railroad with headquarters at Philadelphia, Pa.

R. K. Rochester has been appointed assistant general manager of the Eastern region of the Pennsylvania Railroad with headquarters at New York, N. Y.

A. D. Palmer has been appointed advertising manager of the New York Central Railroad, the Michigan Central Railroad, the Cleveland, Cincinnati, Chicago & St Louis Railway, and the Pittsburgh & Lake Erie Railroad with headquarters at New York.

W. G. Jones, superintendent of the North Carolina division of the Seaboard Air Line Railway, with headquarters at Hamlet, has been appointed assistant to vice-president in charge of operations, with headquarters at Savannah, Ga.

L. W. Thurston has been appointed road foreman of engines of the Portland division of the Boston & Maine Railroad with headquarters at Portland, Me., succeeding **C. P. Brooks,** transferred. **N. L. Wiggin** has been appointed system fuel supervisor with headquarters at Boston, Mass., and **I. R. Annis** has been appointed fuel supervisor Portland division, Portland, Me. **W. H. McClenathan,** has been appointed fuel supervisor, White Mountains, Passumpsic and Southern division with headquarters at Woodsville, N. H., succeeding **Mr. Annis. Charles Furness,** supervisor of engine-houses at Boston, Mass., has been appointed acting master mechanic of the Portland division.

C. F. Smith, assistant to the president of the Cincinnati, Indianapolis & Western Railroad with headquarters at Indianapolis, Ind., has been appointed assistant to the general manager of the Western lines of the Baltimore & Ohio Railroad with headquarters at Cincinnati, O., following the merging of the management of the Cincinnati, Indianapolis & Western with the Baltimore & Ohio Railroad.

Edward L. Henry, who has been appointed to superintendent of the Iowa division of the Chicago & North Western Railway with headquarters at Boone, Iowa.

Obituary

Charles W. Bryan, chief engineer of the American Bridge Company, died on June 25 at New Rochelle, New York. Mr. Bryan had been in charge of the engineering work for the American Bridge Company since 1911. He was born in 1863 at Washington, Mo., and was graduated from the Washington University in 1884. After leaving college he was associated as a draftsman with C. S. Smith, of St. Louis, a well known bridge engineer and the Edge Moor Iron Company, Wilmington, Del. He served as engineer of the designing and estimating office of the Edge Moor Bridge Works and later as chief engineer until the Edge Moor Company became part of the American Bridge Company. He was in charge of contracting for railroad and highway bridges in the district of Pittsburgh and in 1901 was transferred to New York as eastern manager. In 1906 he was appointed chief engineer of the American Bridge Company of New York. In 1911, he was appointed chief engineer of the American Bridge Company, which position he held at the time of his death.

Edwin S. Jackman, of E. S. Jackman & Company, Chicago, agents for the Firth Sterling Steel Company, McKeesport, Pa., died on May 30, at Santa Barbara, Calif., at the age of 62. He was born in East Liverpool, Ohio, April 11, 1865.

Judge James H. Reed, president of Bessemer & Lake Erie Railroad, died at his home in Pittsburgh, June 17. He was born on September 10, 1853, at Pittsburgh, Pa., and was educated at Western University of Pennsylvania. Entered railway service May, 1881, as assistant general solicitor for the Pittsburgh & Lake Erie Railroad. In 1892 he was elected vice-president of the same road. He was United States District Judge for Western District of Pennsylvania. Judge Reed served as vice-president and general counsel until May 1, 1896, when he became president of the Pittsburgh, Bessemer & Lake Eric Railroad, and its successor the Bessemer & Lake Erie Railroad at the same time he also became president of Union Railroad.

Brigadier General Guy E. Tripp, chairman of the board of directors, Westinghouse Electric and Manufacturing Company, died June 14, in the New York Hospital, New York. His death was due to complications following an operation.

Mr. Tripp was born in Wells, Maine, April 22, 1865 and was educated at South Berwick (Maine) Academy, and at the age of 18 entered the employ of the Eastern Railway Company as a clerk, in which service he continued for seven years, being promoted to the position of chief clerk of the Maintenance of Way Department. In 1890 he became storekeeper for the Thompson-Houston Electric Company, which was under contract for the electrification of the West End Railway of Boston. Shortly afterwards he was made traveling auditor for this company in which capacity he visited and reported on many public utilities. In 1897 he became associated with Stone & Webster, construction engineers and operators of public utilities, occupying successively important positions until he was elected vice president of the Stone & Webster Management Association and also of the Stone & Webster Engineering Corporation.

In 1910, when Stone & Webster were called into consultation on the affairs of the Metropolitan Street Railway Company of New York, which had passed into receivership, Mr Tripp was appointed their special representative and in that capacity met the requirements of the situation so acceptably that he was selected as Chairman of the Joint Committee on Reorganization. After he completed his work as chairman of the Joint Committee on Reorganization, he was selected for the position of Chairman of the Board of Directors of the Westinghouse Electric & Manufacturing Company, assuming his duties in the latter position as of February 10, 1912, in which capacity he had continued until his death.

Shortly after the United States entered the World War, Mr. Tripp was selected as Chief of the Production Division of the Ordnance Department, U. S. A. He entered the service in January, 1918, as a Major in the Ordnance Department, and within ten months was made a Brigadier General and Assistant to the Chief of Ordnance of the United States Army. Upon leaving the service immediately after the Armistice, he was awarded the Distinguished Service Medal by th President of the United States for "particularly meritorious service."

Recognizing the importance of the rapid production of war material as a factor in our national defense, Mr. Tripp continued his co-operation with the War Department in its plans for Industrial Preparedness. He is a member of the Advisory Board of the New York Ordnance District and has been unremitting in his efforts in the work of organizing industry on an adequate defense basis. For several years he has held the office of President of the New York Post-Army Ordnance Association.

In 1923-24 Mr. Tripp circumnavigated the globe, spending several weeks in Japan where he effected cooperative arrangements with the Mitsubishi interests, and was decorated by the Emperor with the Second Glass Order of the Sacred Treasure, which is the highest honor that can be conferred by that nation on a private citizen. In the past few years, Mr. Tripp has manifested an especially keen interest in the future of electrical development in America. His articles and addresses on power development attracted wide attention; and a compilation of the more important of these, published by the Knickerbocker Press, New York, under the title of "Superpower as an Aid to Progress," is regarded as an authoritative construction to this subject.

On June 18, 1924, Bates College, Lewiston, Maine, conferred on him the degree of LL.D. in recognition of his many accomplishments. General Tripp was director in a large number of companies and a member of many clubs and societies.

New Publications

Books, Bulletins, Catalogues, etc.

Modern Methods in Coal and Ash Handling: The Link-Belt Company, Chicago, has issued an interesting booklet, which consists of articles previously published separately. These articles are entitled "Coal and Ash Handling"; "Elevators and Conveyors for Coal Handling"; "Belt Conveyors and Skip Hoists"; Bucket Conveyors and Storage Equipment," and "Equipment for Crushnig Coal." This booklet, which is known as Booklet 530, well illustrated with photographs of actual installations, and should prove of interest to those having to do with the handling of coal and ashes.

The company has issued another booklet, 575, entitled "Link-Belt Elevators and Conveyors," which is devoted principally to diagrammatic sketches and photographs of the company's various equipment for handling materials in industrial plants. The company has endeavored to illustrate as many of the applications of elevating and conveying equipment as possible.

Safety code for the Prevention of Dust Explosions: Sponsored by National Fire Protection Association and United States Department of Agriculture and published as Bulletin No. 433 of the Bureau of Labor Statistics. It contains safety codes which have been devised for the prevention of dust explosions in terminal grain elevators. The information will be of great value to those engaged in this business and it may be noted that additional copies of the publication may be procured from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 10 cents per copy.

Track Circuit Hand Book: By M. W. Manz, manager railroad material sales in collaboration with J. B. Weigel and W. P. Bovard engineers of the Ohio Brass Company, Mansfield, Ohio, and issued by that company. This hand book to officers in charge of track maintenance. Special attention is given to the facts concerning the gas welded bonding and the application, maintenance and economy of the low resistance type of bond. An exhaustive study of the methods of making computations for a-c, and d-c, track circuits and also contains a series of tables and charts for use in circuit computations. The book is well illustrated.

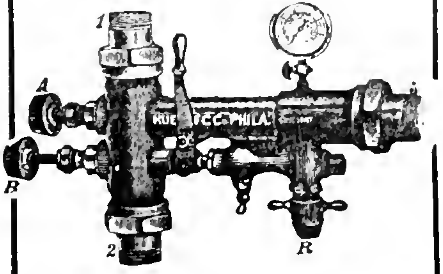
Thomas' Register of American Manufacturers, 1927 edition, Thomas Publishing Company, New York. Price $15.

No changes have been made in the plan or arrangement of the seventeenth editions, but the work has been revised and corrected throughout. It enables the buyer to ascertain quickly the names and addresses of sources for any desired article or the maker of any desired brand of goods. In addition it provides lists of banks, boards of trade, and other commercial organizations, exporters and importers, shipping lines, and forwarding agents. The directory is thoroughly indexed. It will prove a great convenience to purchasing agents.

Steam-Engine and Other Heat-Engines. By Sir J. Alfred Ewing, Fourth edition. University Press, Cambridge, Macmillan Company, New York, 1926. Well illustrated, diagrams, tables. Price $8.50.

The fourth edition of the well-known treatise has been revised throughout and many additions have been made since the appearance of the preceding edition in 1910. The chapters on turbines, boilers, and internal-combustion engines have been largely rewritten and the data on the properties of steam have been revised to agree with those obtained by Callendar. The discussion of thermodynamic principles have been rewritten. This edition, is intended to present the mechanical and thermodynamical aspects of the subject with sufficient fullness for students.

Advantages of Aluminum. The British Aluminium Company, Ltd., have published an informative booklet entitled Aluminium Busbars and Connections. The booklet explains the value of aluminum "as an electric material". The company also issued another booklet entitled Overhead Transmission Lines, which gives an interesting description of steel-cored aluminium conductors Both booklets contain much useful information and should be interesting for those engaged in electrical engineering. Copies of the booklets can be had by addressing the company at the Adelaide House, King William Street, London, E. C. 4, England.



Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

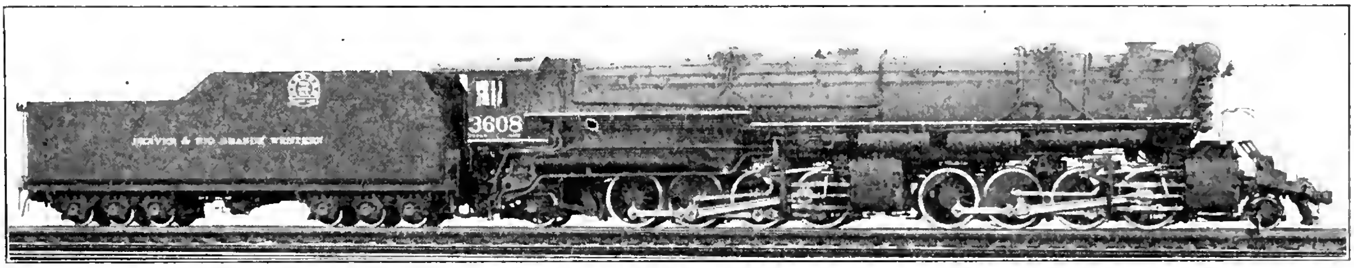
Vol. XL 136 Liberty Street, New York, August, 1927 No. 8

Denver & Rio Grande Simple Mallet Locomotives

Has Largest Horsepower Output of any Coal Burning Locomotive Ever Built

Ten of these engines just delivered by the American Locomotive Company represent the latest effort to produce in a single traction unit the maximum power obtainable within the restrictions of rails, curves, grades and clearances. Permissible rail loads were relatively high and clearances relatively large so that by taking the fullest advantage of these two important factors a locomotive of abnormally large size was made possible for handling the desired tonnage over the ruling grade at the desired speed. To meet the requirements of the curves, the articulated type of locomotive was necessary.

The engine is equipped with the largest firebox, both in grate area and heating surface of any locomotive so far built of which we have any knowledge.


2-8-8-2 Type Simple Mallet Locomotive of the Denver & Rio Grande Western Built by the American Locomotive Company

With a load on the eight pairs of coupled drivers of 559,500 lbs. and with a factor of adhesion of 4.2 a tractive power of 131,800 lbs. is obtained, produced at 70% cutoff in cylinders 26 in. diameter by 32 in. stroke with 63 in. drivers and 240 lbs. boiler pressure.

To supply the steam for the four cylinders of this size, a straight top boiler 102 15/16" inside diameter at front, 110" outside diameter at throat, is provided, containing 284 2¼" tubes and 74 5½" superheater flues 24 ft. long together with a combustion chamber 72 ½" long and a firebox 218" long by 108" wide. The length of the grate is 182" giving a grate area of 136.5 square feet with a Gaines Arch located at the front end of the firebox. Two Nicholson Syphons are applied in each firebox together with American Arch Brick and a type A superheater of 74 units is employed. Bituminous, run of mine coal is fed to the grates by a Standard Type B Stoker, and represents, we believe, the longest and widest locomotive firebox that any make of stoker has yet been called upon to fire. Total evaporating surface of 7,265 sq. ft. is made up of 4,000 sq. ft. in the tubes, 2,550 sq. ft. in the flues, 560 sq. ft. in the firebox, 45 sq. ft. in the arch tubes, and 110 sq. ft. in the syphons. Superheating surface is 2,295 sq. ft.

Arrangement of stays and staybolts in combustion chamber to be such that railroad company can apply a syphon in combustion chamber in the future if they so desire.

The crown sheet is parallel to center line of boiler for full length of combustion chamber and from combustion chamber to door sheet slope to be 3 ft. in 100 in. instead of usual ½ in. in 12 in. With this arrangement firebox tube sheet can be more readily removed and reapplied in repairs, also a more satisfactory arrangement of firebrick and arch tubes and syphon can be worked out.

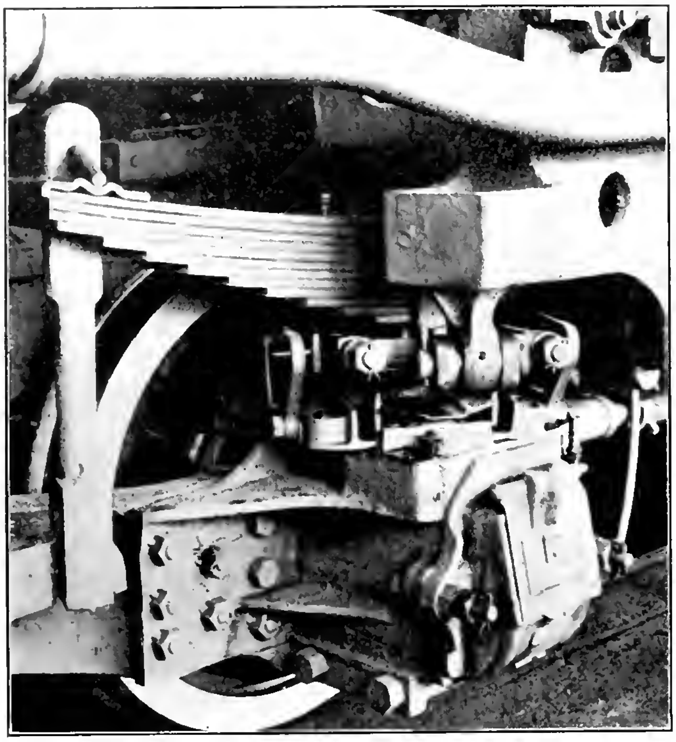
A dry pipe of 12" steel tubing conveys the steam from the dome to the superheater header containing the built in American throttle which governs its supply to the cylinders.

Steam pipes carrying 240 lbs. pressure through swivel joints presented a new problem in ball joint packing design, but by the use of a special Johns-Manville packing and adjustable packing glands, perfectly tight joints were obtained.

The entire steam pipe arrangement always presents considerable of a problem on an articulated engine but it is believed this engine illustrates the simplest arrangement using the least amount of pipe that has yet been produced.

The header has the two regular equal size steam outlets connecting with curved steam pipes following the inside contour of the smokebox. The right hand pipe comes through the smokebox wall below the running board and by an elbow containing an expansion joint turns backward to lead the steam to the rear cylinders. At a point just in front of the rear cylinder saddle it joins a cross-over pipe which leads the steam to each of the rear cylinders. The left hand steam pipe in the smokebox terminates at its lower end in a ball joint packing gland, from which an S shaped connection with slip joint leads the steam to the cross-over pipe feeding the two front cylinders.

The exhaust from the front cylinders returns to the bottom of the smokebox through a similar S shaped connection, while the exhaust from the rear cylinders is brought forward through a pipe on the left side, located similar to the steam pipe on the right side. It will thus be seen that but two outside lines of pipe are required to convey the steam to and from the rear cylinders.



Improved Trailer Truck of Denver & Rio Grande Western Locomotive

The total weight of the engine is 649,000 lbs., of which 40,500 lbs. is carried on the leading truck, 559,500 on the drivers, and 49,000 lbs. on the trailer. The weight of the boiler carried on the front engine is transmitted through a single bearing. The driving wheel base of each engine unit is 16′ 9″, while the total wheel base of the engine is 62′ 10″.

The engine truck is the Alco design, outside bearing truck, using ARA journal bearings, wedges, and box lids, attached to a one piece cast steel frame. Constant resistance centering effort is provided through geared rollers operating on inclined planes, and a central semi-elliptic spring replaces the usual spindle. Alco renewable hub liners are applied to the inside faces of the truck boxes.

The trailer truck is also of Alco design and embraces an improved method of connecting the geared roller centering device to the frame structure so as to perfectly compensate for the radial swing of the truck, while the rollers travel in straight lines.

Each of these locomotives is equipped with Elesco Feed Water heater and one Hancock Non-lifting Injector, also Ashcroft Cutoff Control Gauges and Alemite system of lubrication.

The tender which has a capacity of 18,000 gals. of water and 30 tons of coal, is carried on two Commonwealth six-wheel trucks with clasp brakes. The wheels are 33″ diameter and have 6½ x 12″ journals. The tender frame is also of a Commonwealth steel casting. The weight of the tender loaded is 343,500 lbs. Alco twin drawbars connect the tender to the locomotive.

Other details of the locomotive are given in the accompanying table:

Four Cylinder Simple Mallet Type Locomotive

Cylinders		
Cylinders (4)	26 x 32 ins.	
Valve	Piston, 12 ins. diam.	
Boiler		
Type	Straight top	
Diameter	102 13/16 ins.	
Working pressure	240 lbs.	
Fuel	Soft coal	
Firebox		
Material	Steel	
Staying	Radial	
Length	218⅛ ins.	
Width	108 ins.	
Combustion Chamber		
Length	72½ ins.	
Tubes		
Diameter	5½ ins.	2¼ ins.
Number	74	284
Length	24 ft.	24 ft.
Heating Surface		
Firebox	560 sq. ft.	
Tubes	4,000 sq. ft.	
Firebrick tubes	45 sq. ft.	
Thermic syphons	110 sq. ft.	
Total	7,265 sq. ft.	
Superheater	2,295 sq. ft.	
Grate area	136.5 sq. ft.	
Driving Wheels		
Diameter outside	63 ins.	
Diameter center	56 ins.	
Journal	12 x 14¾ ins.	
Engine Truck Wheels		
Diameter front	33 ins.	
Journals	6½ x 12 ins.	
Diameter back	42 ins.	
Journals	9 x 16 ins.	
Wheel base		
Driving	16 ft. 9 ins. and 16 ft. 9 ins.	
Rigid	16 ft. 9 ins.	
Total engine	62 ft. 10 ins.	
Total engine and tender	108 ft.	
Weight in working order		
On driving wheels	559,500	
On truck front	40,500	
On truck back	49,000	
Total engine	649,000	
Total engine and tender	992,500	
Tender		
Wheels number	Twelve	
Wheels diameter	33 ins.	
Journals	6½ x 12 ins.	
Tank capacity	18,000 U. S. gal.	
Fuel	30 tons	
Tractive force	131,800 lbs.	
Service	Passenger	

C. M. & St. P. Electrified to Seattle

With the opening of a ten-mile extension to the western terminal of the Chicago, Milwaukee & St. Paul Railroad, Seattle is now a terminal of the longest electrified railroad in the world.

This extension brings the total electrification of the St. Paul road to 655 miles. This extends from Harlowton, Mont., to Avery, Idaho, a distance of 440 miles, and from Othello, Wash., to Seattle and Tacoma, a distance of 215 miles. Five mountain ranges are crossed.

The first step in the electrification of the Chicago, Milwaukee & St. Paul Railroad was inaugurated in 1915 over the Rocky Mountain division between Three Forks and Deer Lodge. In 1916 this was extended to Harlowton and westward to Alberton, and to Avery in the spring of 1917. A few years later the Cascade division between Othello and Tacoma was electrified, leaving a gap of only 220 miles between the two electrified zones between the Cascade and Rocky Mountain ranges.

Canadian National Railways Oil Electric Cars

Built at Railroad Company's Shops and Equipped With Beardmore Engines

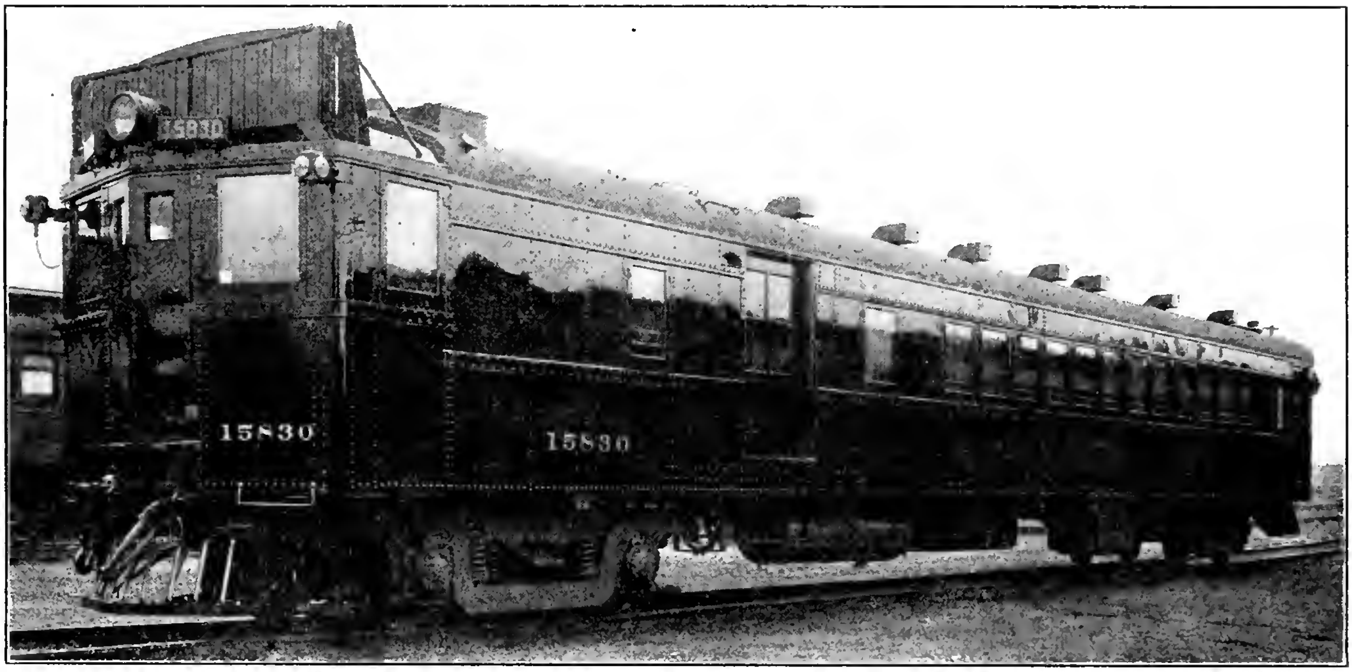
The Canadian National Railways are building at their Point St. Charles shops, Montreal five oil electric cars for passenger service.

The power plant for each car is located at the front end, and consists of an oil engine direct connected to a D.C. Generator. The cars are driven by standard railway type motors mounted on the trucks.

The cars are 73 ft. 9 in. long over the end sills. The engine room occupies 16 ft. 6 in. of the floor space at the front end of the car. In some of the cars the baggage compartment is 27 ft. 2 in. long, while in others 5 ft. 7 in. of this space is utilized as a smoking compartment.

The leading dimensions are as follows:—

Length over end sills, complete	73 ft. 9 in.
Width over side sills	10 ft. 0 in.
Width inside	9 ft. 8¼ in.
Height from rail to top of roof	12 ft. 7 in.
Height inside from floor to ceiling	8 ft. 0 in.
Height overall	14 ft. 0 in.
Truck Centers	33 ft. 3 in.
Total wheel base	[illegible]
Truck wheel base	8 ft. 0 in. & 7 ft. 0 in.
Length of engine room inside	16 ft. 6 in.
Length of baggage compartment, clear	27 ft. 2 in. & 21 ft. 7 in.
Length of smoking compartment, clear	" 5 ft. 7 in.
Length of passenger compartment, clear	22 ft. 7 in.
Weight on rail, with equipment but with no live load	133,000 (Estimated)



Oil-Electric Car of the Canadian National Railway

The car bodies are of steel construction throughout and the steel frames were built by the Canadian Car & Foundry Company, Limited, and finished by the Railway.

The partitions between engine room and baggage room are of steel and so constructed that they can be removed if necessary to work at power unit.

The inside finish is birch stained mahogany with 3/16 in. Haskelite ceiling painted cream color. Double doors are applied throughout except in engine rooms where a single floor 1¼ in. thick is used and covered with checkered aluminum floor plates. On all other parts of cars, floor consists of one layer 13/16 in. white pine and a top floor of ⅝ in. B. C. fir, with one layer of J. M. No. 50 asbestos and asphalt waterproof felt between.

The side lining below the windows is 3/16 in. Haskelite painted to match interior finish.

Single windows of cherry, Canadian National standard size, are applied with curtains, and storm sash are provided for winter use.

Parcel racks are applied on each side of passenger compartments, the full length of same. Below windows, insulation is 3 ply Salamander, above windows 3 ply Salamander and in ceiling 3 ply Salamander is used.

The roof is 5/16 in. Haskelite covered with No. 6 canvas laid in white lead.

The outside finish is Canadian National Railway Company's standard coach color, dark green with lettering and numbers in gold leaf.

The seats are Heywood Wakefield type spaced 2 ft. 10 in. between centers and upholstered in mohair. The seats accommodate three people on one side and two on the other, giving a total seating capacity of 37.

Electric lighting is provided from storage batteries at 32 volts and conduits for lighting circuits are carried over side plates and let into wooden carlines. Light fixtures are placed on center line of car. Conduit is also used throughout for power and control circuits. Ventilation is provided by exhaust type ventilators in roof. Smith hot water heaters, type O.C. 2A, are used, located in baggage room. All pipes for heating systems are W.I. One car equipped with Vulcan Tubing.

All trucks are the 4 wheel type with equalizer springs. Both trucks have 36 in. rolled steel wheels, S.K.F. boxes and bearings, cast steel frames and bolsters. The front truck carries two motors and has 5½ in. x 10 in. journals. The rear or trailing truck has no motors and has 5 in. x 9 in. journals.

The brake equipment is Westinghouse Schedule A.M.F. The air pressure is supplied from one D.H.-20 compressor controlled by S-6-A governors. The braking ratios are based on 50 lbs. cylinder pressure, being 83% on the front truck and 75% on the rear truck. The front truck is equipped with A.S.F. Suburban Type Simplex Clasp Brake. The rear truck is fitted with single type brake of company's design. Both units are equipped with the Universal Draft Gear Attachment Company's hand brake booster and vertical operating ratchet handle. The standard train air communicating signal system is used.

Golden Glow headlights are mounted on the roof at the front end of each car, also Canadian National standard number lamps and Strombos Horns. Brackets and electric connections are provided for marker and classification lamps. There are light pilots on the front end made of angle iron and well braced.

A locomotive type bronze bell is suspended from center sills under baggage compartment and is operated by an Internal Quick Acting Bell Ringer made by Transportation Devices Corporation, Indianapolis. Miniere window cleaners are used on the front window near operator.

Hanlon sanders provide sand to the front of the front truck wheels and the rear of the rear wheels of the front truck. Sand boxes are located in engine room and are filled through holes in roof.

The tanks for water and fuel oil are made of copper bearing steel plate and sit in engine room. The piping is wrought iron; in a few places copper is used. The water tank has a capacity of 80 Imperial gallons, the fuel oil tank 150 Imperial gallons and an auxiliary tank of 150 gallons is secured to underframe.

The engines used on these cars were manufactured by William Beardmore & Company, Limited, of Glasgow and London. They conform to a modified Diesel cycle of the solid injection 4 stroke cycle type, and are arranged with six cylinders in line. The cylinders have 3¼ in. bore and 12 in. stroke, and develop 300 B.H.P. at 750 R.P.M. The engine and flywheel weigh approximately 6,900 pounds.

One of the special features of this engine is its very low weight per horse power, which has been obtained entirely by a scientific use of materials. The thicknesses of the materials have been reduced to a minimum consistent with the required strength using high tensile steels and special alloys throughout. The crank case is cast steel; the cylinder liners, forged steel; cylinder heads, cast aluminum; valve seats, alloy steel; pistons, forged aluminum; crank shaft, special forged alloy steel; sump cover, sheet steel; connecting rods, special forged steel. The aluminum pistons are fitted with five cast iron rings and one oil scraper ring. The exhaust from each cylinder is carried vertically up through the roof.

The fuel oil is carried in a 150 gallon tank mounted in the engine room from which the fuel for the engine is drawn. An additional supply of fuel oil is carried in a 150 gallon tank suspended beneath the car from which the oil is forced up into the engine room tank by air pressure. The fuel circuit is from the engine room tank by gravity to an Auto-Klean filter, then to the gear pressure pump, from which it is delivered at about 30 pounds pressure to the distributing plunger pumps, of which there is one for each pair of cylinders. This pump delivers the oil to the atomizers at from 8,000 to 10,000 pounds per square inch.

The oil is forced under pressure to all working bearings including those of the camshaft. Oil is drawn from the well in the sump at the gear case and of the engine, and is then forced at 40 pounds pressure through a filter to the bearing from which it drains back to the sump. The sump acts as the lubricating oil storage, in which the oil is air cooled.

A centrifugal pump is fitted to circulate the cooling water through the engine. This pump is mounted on the main gear case and is easily detached for examination. A flow indicator is provided in the cooling water circuit which indicates a stoppage of flow by extinguishing a lamp in front of the operator.

A centrifugal type governor driven off the crank shaft is coupled to the fuel pump controls and so arranged as to increase or decrease the oil supply to the fuel distributing system. It is fitted with an emergency device to cut the fuel pumps out of action should the R.P.M. of the engine, for any reason, increase above the designed speed.

The electrical equipment of the six cylinder car was manufactured by the Canadian Westinghouse Company. The generator is a 198 K.W. 300 volt D.C., 600 amperes compound wound machine mounted on a common bedplate with and rigidly connected to the engine. Liners are placed between bedplate and car sills to absorb vibration. On the same shaft with the generator is mounted a 5.6 K.W. 84 volt auxiliary generator. The balance of the electrical equipment consists of two 569 C-4 600 volt, 215 H.p. Railway motors, mounted on the front truck and connecter through helical gears at a 20:59 ratio; the controller is located at front and connects the motors to the generator, governs direction, engine starting, and manual throttle control of engine speed; and the necessary control switches.

An 84-volt M.V.A. 17 Ironclad Exide Battery is carried underneath the rear half of the car, suspended from the floor in a steel battery box on each side of the car. This battery furnishes starting current for driving the generator as a motor. The battery is charged from the auxiliary generator when its voltage is higher than the battery voltage.

Condition of Locomotives and Freight Cars

The Car Service Division of the American Railway Association announces that Class I railroads on July 15 had 9,240 locomotives in need of repair or 15.1 per cent of the number on line.

This was an increase of 481 compared with the number in need of repair on July 1, at which time there were 8,759 or 14.3 per cent.

Of the total number of locomotives in need of repair on July 15, 5,128 or 8.4 per cent were in need of classified repairs, an increase of 273 compared with July 1, while 4,112 or 6.7 per cent were in need of running repairs, an increase of 208 compared with the number in need of such repairs on July 1.

Serviceable locomotives in storage on July 15 totaled 6,463, compared with 6,219 on July 1.

Freight cars in need of repair on July 15 totaled 145,118 or 6.3 per cent of the number on line, according to the American Railway Association.

This was an increase of 3,685 cars above the number reported on July 1, at which time there were 141,433 or 6.2 per cent. It was, however, a decrease of 22,304 cars compared with the same date last year.

Freight cars in need of heavy repair on July 15 totaled 105,642 or 4.6 per cent, an increase of 3,157 compared with July 1, while freight cars in need of light repair totaled 39,476, or 1.7 per cent, an increase of 528 compared with July 1.

Locomotive Feed Water Heating*

Description of Various Types of Heaters in Use, Their Application and Advantages Effected Under Operating Conditions

By W. C. Hamm, Mechanical Engineer, Central Vermont Railway

The subject of locomotive feed water heating is becoming increasingly important from the standpoint of transportation. This is due to the fact that with the constantly mounting expense of operation, any device that can be applied to a locomotive to increase its efficiency as an operating unit and yet not introduce elements detrimental to its handling in service must receive serious consideration.

Whereas the preheating of the boiler feed water has long been standard practice in stationary and marine service, it is only in recent years that it has become sufficiently developed to be applied generally in the locomotive field.

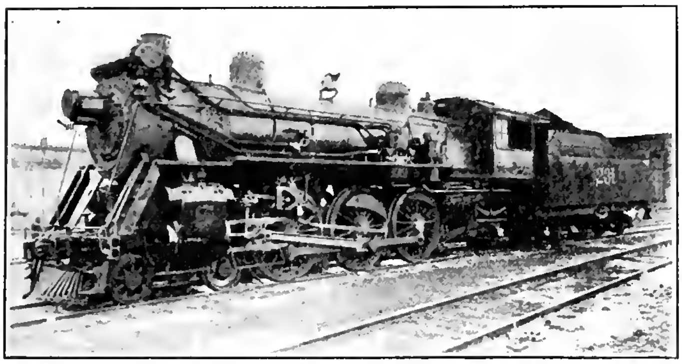


Fig. No. 1—Locomotive Equipped With Elesco Heater

There have been many papers written on this subject from a purely theoretical standpoint, but this paper is intended to present the subject in general, to emphasize the benefits which may be expected from the application of a feed water heater, and to present some actual results obtained in service.

Feed water heaters have received attention from the days of the earliest locomotives and experiments have been carried out with many different designs. However, in the last few years the need for a successful heater has been emphasized by the increasing cost of locomotive fuel.

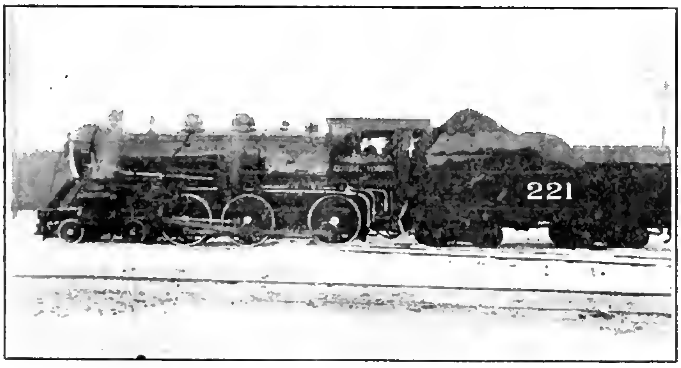


Fig. No. 2—Locomotive Equipped with Coffin Heater

As a result, a feed water heater was produced and applied to a large Pacific type locomotive in the United States in the year 1916 which has since developed into one of several very satisfactory designs. Although the further development was somewhat hindered by war conditions, yet at the present time approximately 4,100 are in service on locomotives on this continent.

Meanwhile, on European railroads this same development has been taking place only somewhat more rapidly on account of the higher proportionate cost of fuel and the need for a more rigid operating economy, and at present there are several thousand locomotives equipped with devices of this nature.

Advantages to Be Derived

The savings and benefits to be derived by the application of feed water heaters to locomotives take several different forms, all of which should be taken into account. First is the important benefit accruing from fuel saving. A second equally important one is the possible increase in boiler capacity attained by its application whereby a heavier tonnage train can be handled over a division in the same or shorter time, resulting in an increased gross ton-miles per hour figure. Which of these two points should be stressed in any particular application depends upon the physical characteristics of the road and equipment.

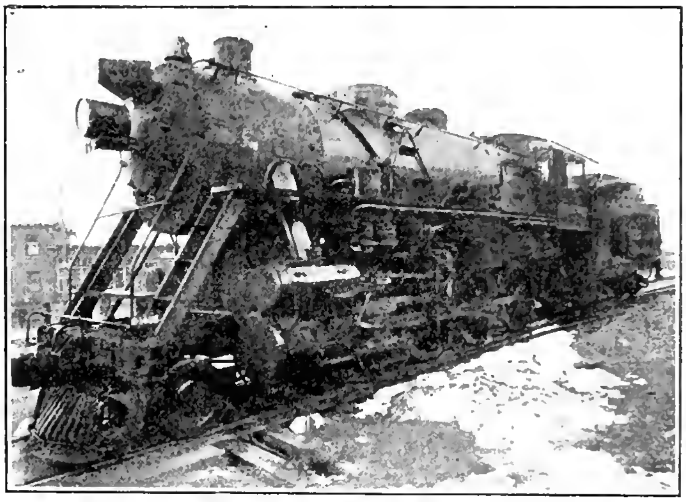


Fig. No. 3—Locomotive Equipped With Worthington Heater

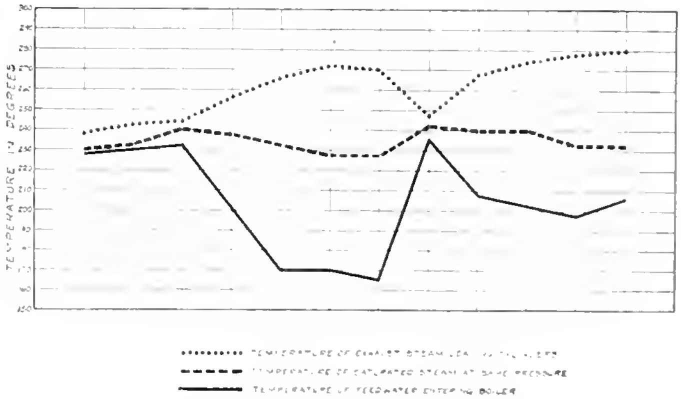


Fig. No. 4—Curve Showing Decrease in Feed Water Temperature Due to Superheat in Exhaust Steam

The maximum horsepower of a locomotive, which, of

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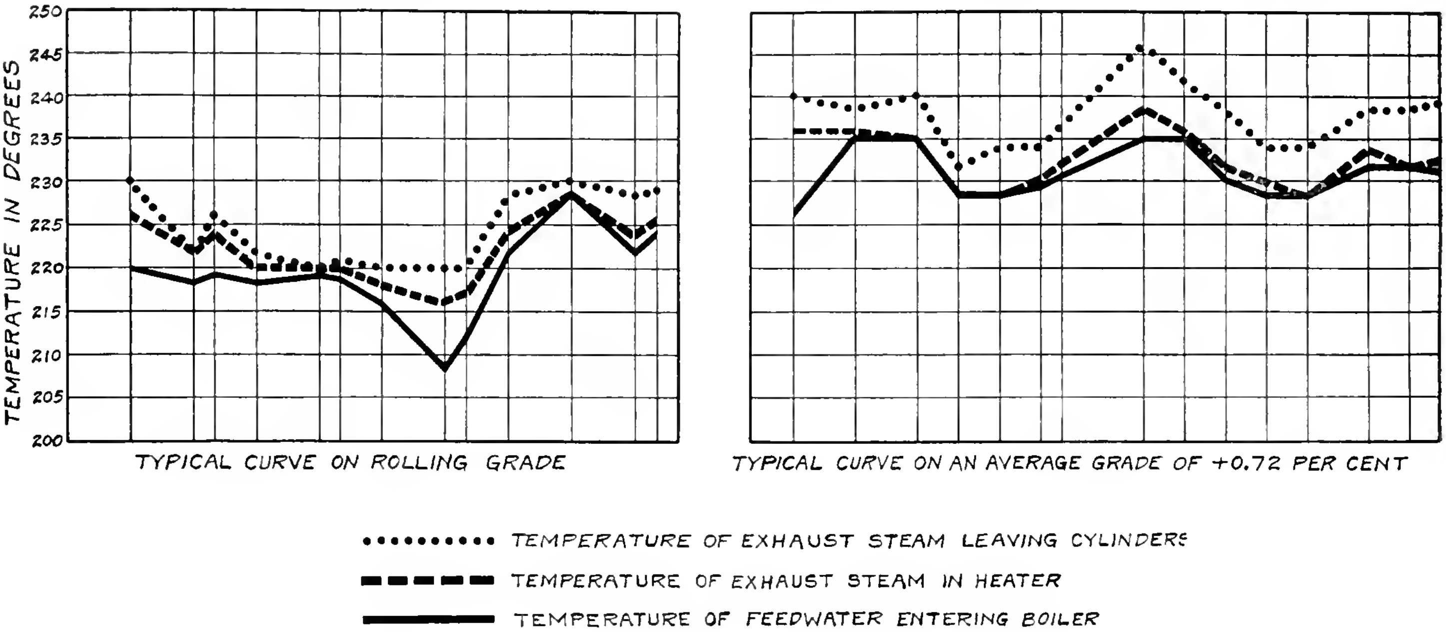
*A paper presented to the Engineering Institute of Canada.

course, is the period of the greatest steam consumption, is not developed until a speed of around twenty-five to thirty miles per hour is attained assuming that the locomotive is also being worked to the maximum. Therefore, if the territory in question is a low gradient line where, in order to obtain the best transportation results heavy trains are to be handled at speed, any increase in boiler capacity is a direct boon to operation and this point becomes the more important of the two. At the present time, one of the principal aims of locomotive design is to increase the capacity and efficiency of the boiler.

On the other hand, if the profile of the engine district has some heavy grades and the boilers are reasonably well designed, then, under ordinary working conditions, the theoretical maximum steam consumption will never be reached, for when the locomotive is working the hardest it will be at a relatively low speed while on the remaining stretches the locomotive will be underloaded, due to the fact that the grades have set the tonnage rating. Under these conditions, which exist in many places, the feed water heater is not required as a boiler capacity increaser, but full advantage can be taken with it as a fuel saver. Other lines very often are choppy, that is, they have numerous sharp grades that cannot be taken at momentum and which limit the tonnage rating. In many such cases at the present time booster engines of the trailer and tender truck types are being used with the regular locomotives so as to assist at these hand points, resulting in a more economical tonnage loading over the engine district. As this becomes an added drain on the boiler, the application of feed water heaters will increase their capacity and so furnish sufficient steam at the critical points.



TYPICAL CURVE ON ROLLING GRADE

TYPICAL CURVE ON AN AVERAGE GRADE OF +0.72 PER CENT

Fig. No. 5—Curve Showing Temperatures on Light and Heavy Grades

Saving in Fuel

Now, as to fuel saving, a few explanatory figures will be given as to how this can be arrived at theoretically and then later some figures obtained in actual service.

It has been found that out of every pound of coal fired into the firebox of a locomotive only about seven per cent is turned into useful work at the drawbar. The other ninety-three per cent is consumed partly in the operation of the various auxiliaries such as the air pump, stokers, power operated grate shakers, etc., while the greater part is lost through the exhaust steam from the cylinders, hot gases from the stack, pops and ashes.

The hot gases from the stack represent approximately twenty-five per cent of the total and the exhaust steam about fifty-eight per cent. Therefore, it can be seen that the greatest loss is in the exhaust steam and that this provides a source of power which, if reclaimed, will result in substantial savings.

In the many years of experimentation in the past, feed water heaters were designed to utilize the loss represented in the exhaust steam, while economizers were developed to reclaim that in the gases from the stack. This latter development has not become successful as yet for two reasons. First, the very hot exhaust gases, ranging from temperatures of 450° to 1,100° Fahrenheit, in striking the cold economizer tubes, cause a film of moisture to be precipitated on the outside surface of the tubes, and the soot which naturally collects forms a non-conductive medium, preventing the transfer of heat to the feed water. Secondly, a chemical action is set up in the feed water which causes the precipitation of part of the solids in this water, thus forming a scale on the water surface of the tubes. For these reasons and the fact that the lack of space in the locomotive front end does not allow the application of a two-stage economizer, the successful development of an apparatus of this type has been prevented. Although at present, outside of European experiments, one company at least in America is working on a combination feed water heater economizer system for locomotive use. There still remains, however, the possibility of saving a portion of the heat wasted in the exhaust steam by transferring it to the feed water before the latter goes to the boiler, and it is this phase of the problem that will now be considered.

The unit of heat measurement is, of course, the British thermal unit, (B.t.u.), which is the amount of heat required to raise the temperature of a pound of water one degree, from 62° to 63° F. If we assume that the average temperature of the water in the tender tank, summer and winter, will be 55°, it is found on consulting tables of the properties of steam that 1,311 B.t.u. must be supplied to each pound of water at 55° in order to convert it into steam of 200 pounds boiler pressure with 250 of initial superheat, the conditions which will be assumed as an example. Further, it will be assumed that, considering the service in which the locomotive is to be operated and the draught requirements, the average running back pressure will be 5 pounds, and steam tables show that the temperature of exhaust steam at this pressure will be 225° F.

It is now possible to estimate the saving from the operation of a feed water heater under these conditions, and it will be assumed that the locomotive requires 38,000 pounds of steam per hour to develop its maximum power in the cylinders and that five per cent of its boiler capacity is required to cover radiation losses, requirements for train heating, etc. A total boiler capacity of 40,000 pounds of steam per hour is therefore assumed, which also means that 40,000 pounds of feed water per hour will have to be heated through 160°. The heat required per hour to heat the feed water is therefore:

$$40{,}000 \times 160 \qquad 6{,}400{,}000 \text{ B.t.u.} \quad (1)$$

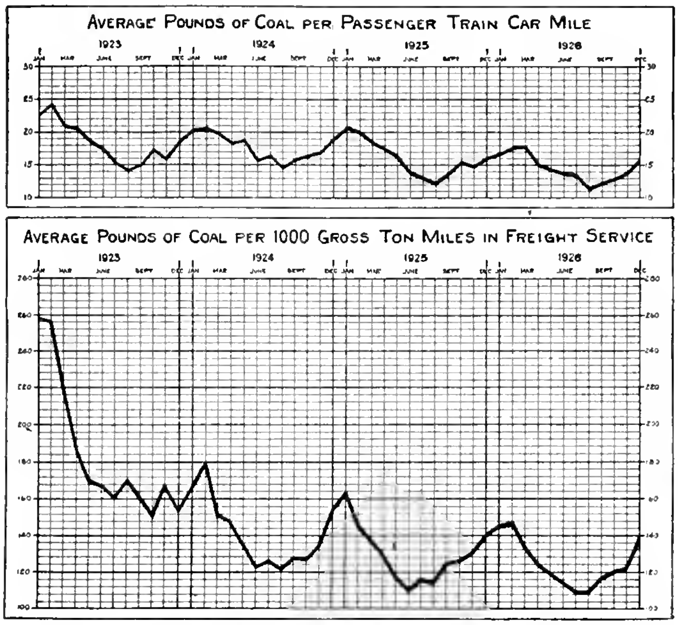


Fig. No. 6—Locomotive Fuel Consumption in Passenger and Freight Train Service

From the steam tables it is found that each pound of exhaust steam in being condensed from steam at 225° to water at the same temperature supplies 962 B.t.u. to the feed water; the amount of exhaust steam required to heat the feed water is therefore:

$$\frac{6{,}400{,}000}{962} = 6{,}650 \text{ pounds per hour} \quad (2)$$

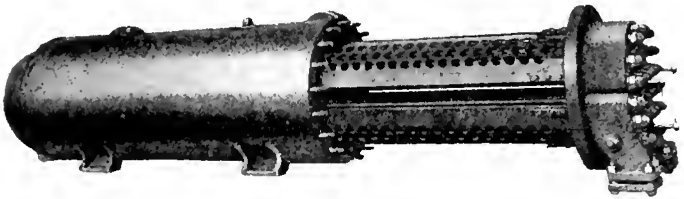


Fig. No. 7—Elesco Heater

The total heat expended in producing 40,000 pounds of superheated steam per hour from cold water at 55 is:

$$1{,}311 \times 40{,}000 = 52{,}440{,}000 \text{ B.t.u. per hour} \quad (3)$$

In order to effect an economy of one per cent on this amount, it would have to be diminished by one one-hundredth or 524,400 B.t.u. per hour; but as appears from (1) the feed water heater actually saves 6,400,000 B.t.u. per hour, so that the saving on the total heat expended is:

$$\frac{524{,}400}{6{,}400{,}000} = 12.2 \text{ per cent} \quad (4)$$

Further, this economy is effected by the use of a proportion of the total exhaust steam which will amount to (after allowing for the volume of exhaust steam from the auxiliaries which may be utilized in the feed water heater) between fourteen and fifteen per cent of the total exhausted from the cylinders.

The foregoing shows that an appreciable and direct saving can be obtained from a feedwater heater in regard to fuel economy. There are, however, other factors that work both with and against it. First, there is the added drain on the boiler due to the live steam consumption of the feed water pump. This will vary from one and one-half to two and one-half per cent of the boiler capacity, depending on the type of pump used and its physical condition. As an offset to this apparent loss is the increased evaporating efficiency of the boiler obtained by the lower fuel rate required. As has already been seen, a large amount of heat has been reclaimed from the exhaust steam, which, of course, has resulted in an increased evaporation of pounds of water per pound of coal. Therefore, for the same boiler output, less fuel is required and the firing rate in pounds of coal per square foot of grate per hour is decreased. This will increase the boiler efficiency approximately four to five per cent, depending on the service in which the locomotive is used and the point of cut-off at which it is worked.

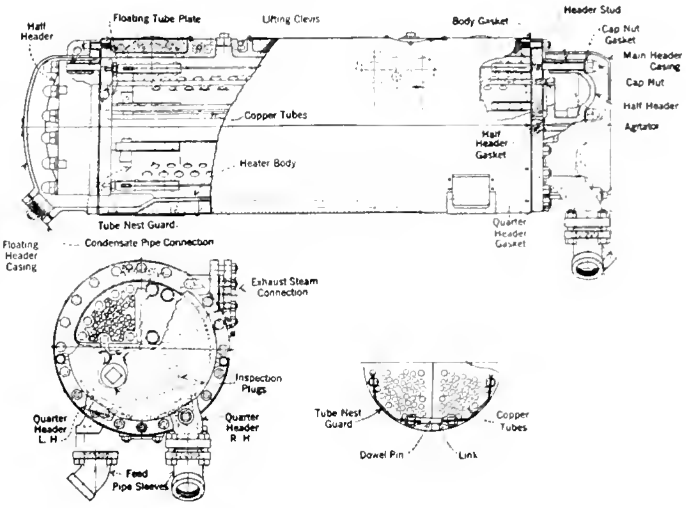


Fig. No. 8—Details of Elesco Heater

As less coal is burned, there is formed a smaller volume of gases that has to be exhausted through the stack. This in turn means that the exhaust blast can be softened and a reduced cylinder back pressure maintained. A reduction of two pounds in back pressure should readily be obtained which on a two hundred pound boiler pressure engine will be increased in cylinder power of one per cent.

A derimental factor which can generally be expected when a feed water heater is applied to an old locomotive is a loss in initial superheat. This has been found to average about twenty degrees on some locomotives tested. The loss is caused by the lower fuel consumption whereby the ratio of the exhaust gases to the steam consumption is lessened. In new locomotives this fact can be taken care of in the design and a large proportionate superheating surface can be installed. However, this point, is not particularly serious as the apparent loss is partially at least compensated for in the reduced cylinder back pressure.

Effect of Superheat in Exhaust Steam

This brings up a point which the writer believes is not thoroughly understood at present and which will have to be worked out in the matter of design and proportion, i.e., the effect of superheat in the exhaust steam. It has been found by experience that the transfer of heat to the feed water is quite seriously affected when the temperature of the exhaust steam entering the heater is above that of saturated steam of the same pressure. And that the greater this difference becomes the more marked becomes the effect. Therefore, if a locomotive is so designed and worked in service that the exhaust steam from the cylinders is in a superheated form, the effect, particularly in the closed type of feed water heater, is to reduce the delivery temperature of the feed water, for there is apparently but little heat absorption through the tubes in the area of this highly heated steam. This has been found to exist as the result of many test readings and may be the result of several contributing causes. A typical curve illustrating this condition is shown in figure No. 4.

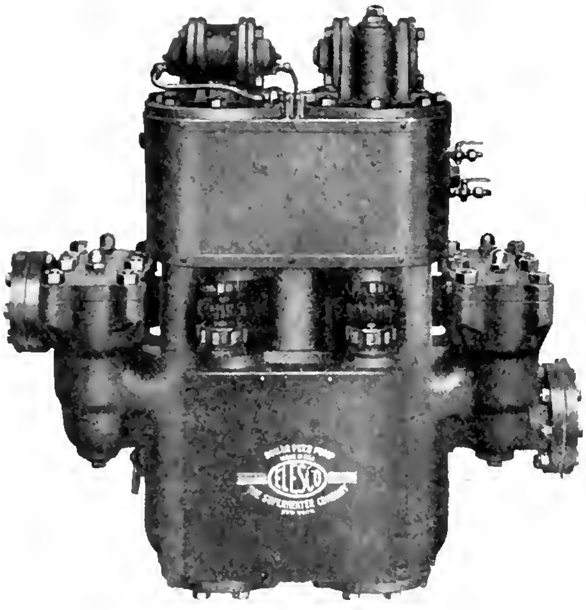


Fig. No. 9—Two-Cylinder Elesco Pump

Saving of Waste

Another feature of the feed water heater which is often important from the transportation viewpoint is the water saving. In all systems in use in America, the condensate from the exhaust steam utilized in the feed water heater is saved and returned to the boiler. This water, which varies in amount somewhat with the working of the locomotive, approximates 10 per cent of the whole as an average. This condensate is in effect distilled water and thereby eliminates immediately a corresponding per cent of the impurities carried in with the raw water, and will prevent to that extent the formation of scale and the accumulation of mud in the boiler. In bad water districts the good effect of this is very noticeable on not only the maintenance of the boiler but on the cost of the water, as a smaller amount of the treated water is required. In fact, one large western railroad system in the United States found that feed water heaters paid for themselves on the item of boiler maintenance alone. The return of the condensate to the tender virtually results in an equivalent larger tank and in many cases eliminates a water stop with its attendant delays.

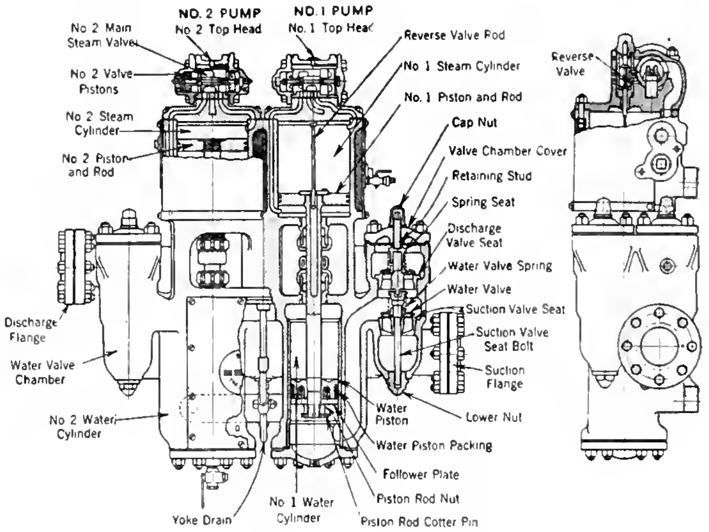


Fig. No. 10—Details of Two-Cylinder Elesco Pump

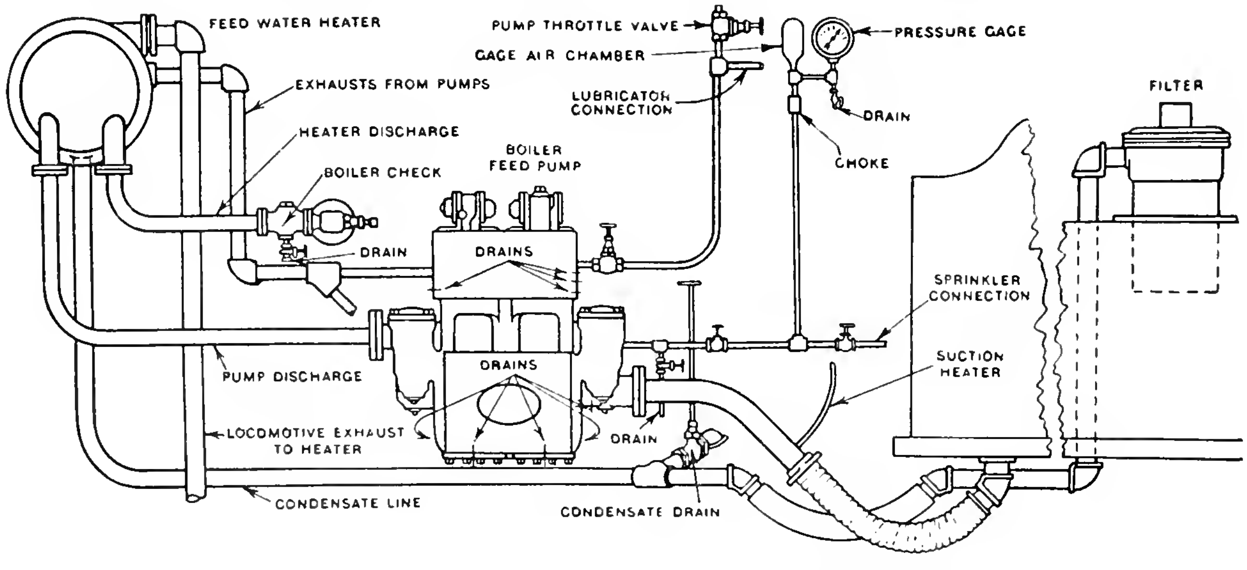


Fig. No. 11—Piping Diagram Showing Layout and Application of Elesco Heater

The Injector

It may not be amiss to say a word here about the well-known injector. In itself it is a feed water heater, inasmuch as the live steam required by it to force the water into the boiler is condensed and mixed with the water, thereby heating it to a high temperature. This, however, does not result in other than an incidental saving, as the heat units used are a drain on perhaps an overloaded boiler and not a recovery of the heat units going to waste. An injector has the advantage of being a simple device, light in weight and easily maintained, although at its most efficient state it will deliver only about ten pounds of water to the boiler per pound of live steam, while the various feed water heater pumps will deliver anywhere from forty to sixty-six pounds.

The exhaust steam injector is also being developed into a satisfactory device, and it utilizes in its operation exhaust steam the proportion of which varies with the working of the locomotive. If standing or drifting live steam has to be used entirely. The injector is light in weight compared with a feed water heater and much cheaper, but at present the control is rather complicated. About three hundred and fifty have been applied in America, although quite a number are in service in England.

Results

Some average results and figures obtained in actual service from some fifty feed water heaters of both the closed and open types, operated in freight and passenger service are given in the following table and curves. The curves shown in figure No. 5, which are of a representative run, show the heat transfer obtained from the exhaust steam through the heater to the delivery water.

Table No. 1 gives the results of a number of typical runs. No doubt some may take exception to the high percentage of savings shown, since they are so much in excess of possible theoretical calculations. In all cases, however, the coal and water were carefully measured. Accurate records were kept, and they are borne out by check records that are constantly being made and by fuel consumption statistics. There are so many elements affecting and improving the operation of the locomotive when a feed water heater is applied that it is rather impossible to separate one from another in ordinary running and test service. Therefore, a complete explanation cannot be made of them, but these results can be taken as the average obtained in everyday service as shown in table No. 1.

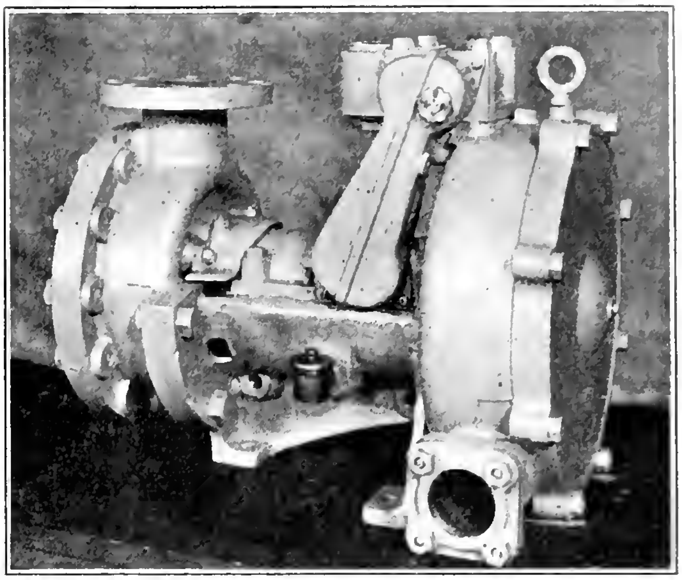


Fig. No. 12—Coffin Pump

TABLE NO. 1—RESULTS OBTAINED ON A NUMBER OF TYPICAL RUNS

Service	Type of Engine	Length of Run in Miles	Weight Train In Tons	Per Cent Increase in Evaporation Feed Water Heater over Injector	Per Cent Decrease in Fuel Consumption Feed Water Heater over Injector	Pounds Coal per Square Foot Grate per Hour	
						Feed Water Heater	Injector
Fast Passenger	4-6-2	186	650	23.9	22.8	49.9	62.1
Local Passenger	4-6-0	117	284	19.0	15.8	39.5	47.9
Fast Freight	2-8-0	117	1,590	12.8	15.2	50.6	56.6
Fast Freight	2-8-0	117	1,540	19.7	9.7	53.5	57.1
Slow Freight	2-8-0	72	1,180	24.0	9.7	50.2	57.3

Effect on Terminal and Shop Facilities

There is another phase of the subject that should be considered equally as well as the saving in fuel and the train operating benefits, and that is the effect on terminal and shop facilities due to the added maintenance expense. This not only directly affects the locomotive as an economical unit but might seriously increase shop forces. However, from records carefully complied, in a certain instance, this expense including everything in regard to maintenance, that is, labor, material for repairs,

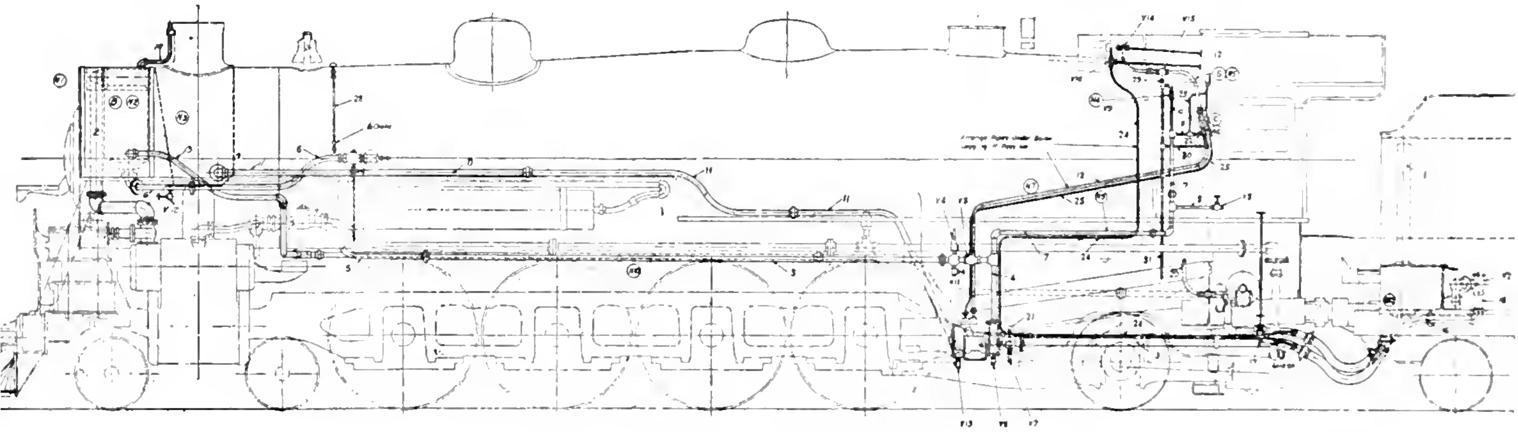


Fig. No. 13—Piping Diagram of Coffin Water Heating System running expenses, general overhaulings and monthly inspections, has been found to average 24.1 cents per 100 miles. This represents a test of a set of twenty-three heaters, including both closed and open types that were between three and four years old. For another set of twenty-four heaters under two year old this average cost is only 4.15 cents per 100 miles. These figures represent maintenance costs in a good water district and would naturally be increased under more adverse conditions.

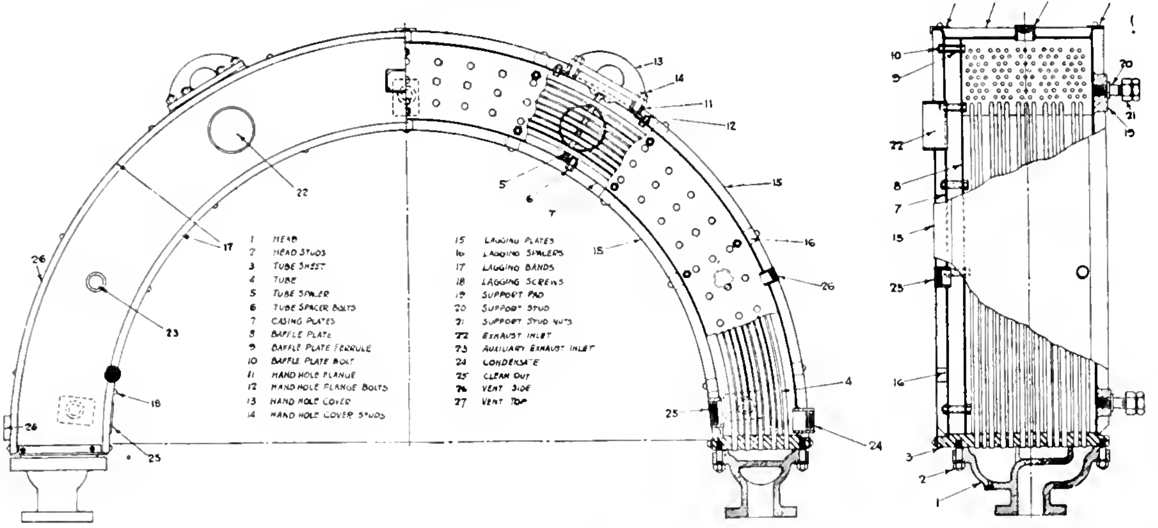


Fig. No. 14—Details of Construction of the Coffin Heater

To show just what these savings will amount to as regards locomotive and fuel performance, the following figures are given:

First cost of feed water heater applied	$2,500.00
Interest on investment and deferred maintenance at 12 per cent	300.00
Maintenance for 40,000 miles at 24.1 cents per 100 miles	96.40
Total cost per year	$396.40
Cost of 2,947 tons of coal (injector fed engine), at $5.35 per ton	$15,765.45
Average fuel saving in freight service of a feed water heater equipped locomotive over one injector fed (from table No. 1), 11.5 per cent	338 tons
Saving in fuel, 338 tons coal at $5.35 per ton	$1,808.30
Net saving per year of feed water heater equipped locomotive	$1,411.90

As a concrete illustration, the Central Vermont Railway can be considered, one which at the present time forty-eight and one-half per cent of the locomotives are equipped with feed water heaters, while within the next few months this will be increased to sixty-six per cent. These feed water heater equipped locomotives handle approximately ninety-five per cent of the road freight tonnage and fifty per cent of the steam locomotive operated passenger traffic in car miles. A very appreciable saving in fuel has been obtained since the application of feed water heaters, and this is shown graphically by the curves in figure No. 6. It is not intended to convey the impression that all the improvements is due to this one source, as it is not. Part is attributable to the scrapping of obsolete power and its replacement by modern units and part to better operating conditions. This in turn cuts down train delays, but, nevertheless, since the application of feed water heaters was started the fuel consumption rate as shown by these curves, has decreased with each new lot of heaters applied, and therefore bears out very clearly the fact of the economies to be obtained from this source.

The several designs of heaters that are being developed on American railroads can be divided into two general types, the closed and the open. In the first the feed water does not come into direct contact with the exhaust steam, while in the latter type the exhaust steam is condensed by and is carried on into the boiler with the feed water.

In the closed type, the two heaters that are most extensively applied are the Elesco and the Coffin.

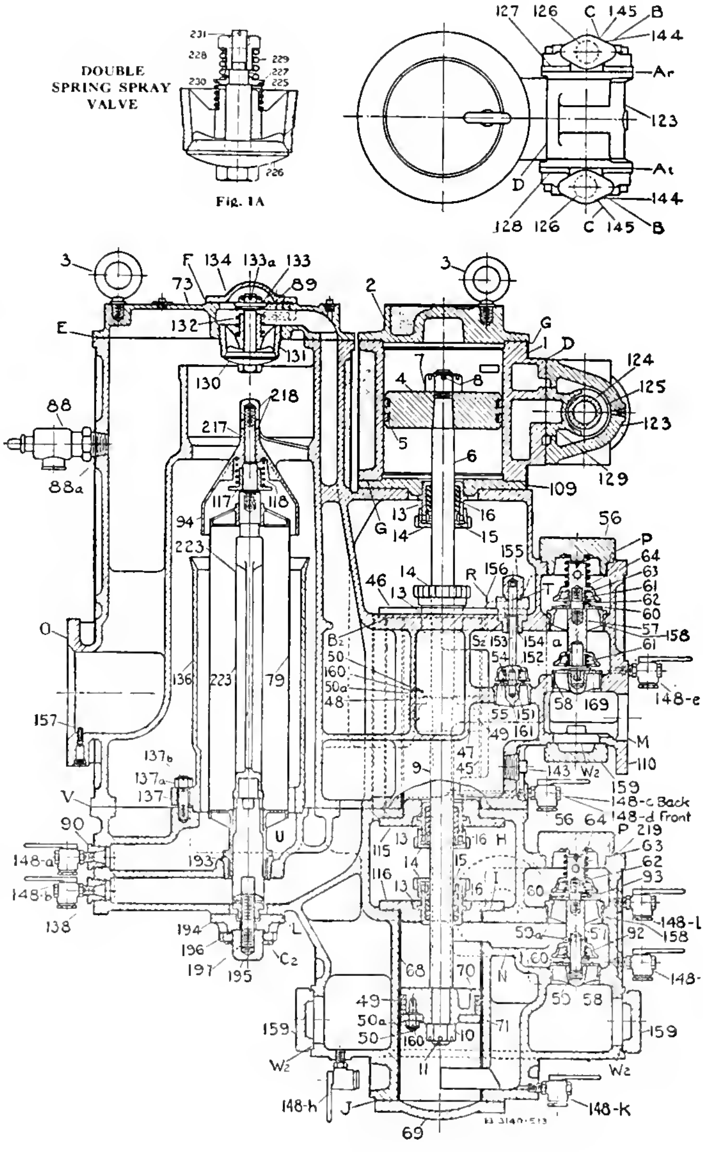


Fig. No. 15—Construction of Worthington Pump and Heater

The Elesco consists of a cylindrical heater containing four nests or passes of small tubes located generally on top of the smoke box ahead of the stack which allows the condensate to drain back to the tender tank by gravity. This heater is shown in detail by figures Nos. 7 and 8. The exhaust steam is taken from the cylinders and surrounds the small tubes through which the feed water is forced to the boiler, while the condensate formed from the exhaust steam drains back to the tank and is then used over again. A two-cylinder pump, shown in figures Nos. 9 and 10, located on the side of the boiler and driven by live steam, sucks the feed water from the tank and forces it under pressure through the heater into the boiler. The piping diagram, figure No. 11, shows the general layout and application of the Elesco feed water heater.

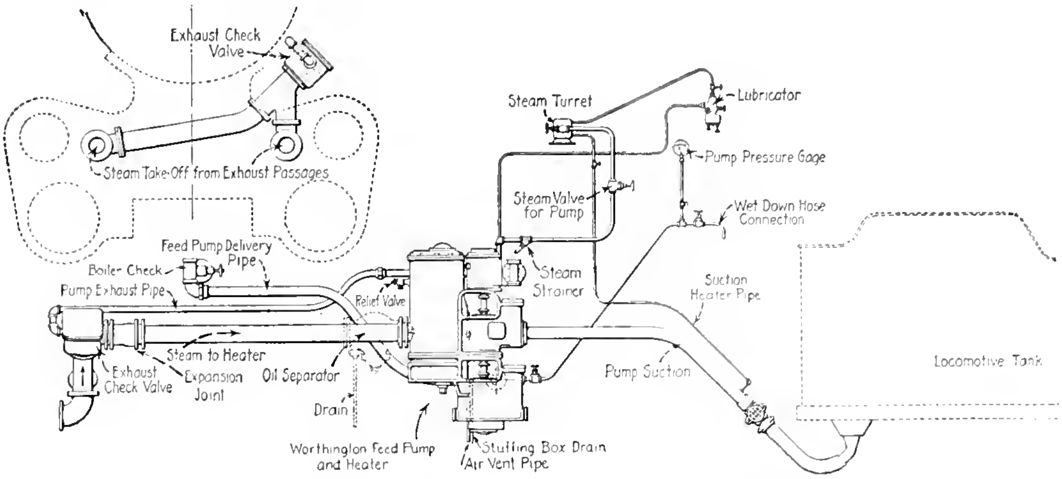


Fig. No. 16—Piping Diagram Showing General Layout of a Typical Application of Worthington Heater

The Coffin feed water heater is designed in a curved shape to conform to the contour of the locomotive smokebox. It is rectangular in cross-section and has five nests or passes of small tubes surrounded by the exhaust steam, through which the feed water is forced by the pump. This heater is vented to the air and the condensate from it is carried back to a small auxiliary heater in the tank, where it is thoroughly mixed with and preheats the tank water before going to the pump, thereby increasing the efficiency of the heater. The pump is the centrifugal type with two rows of buckets in the steam end and has an automatic governor which limits its speed. It is light in weight and can generally be located on a bracket attached to the engine frame under the cab. If desired, the exhaust from the pump can be run into the condensate line and returned to the auxiliary heater for preheating purposes. Figure No. 12 shows the Coffin pump, while figure No. 13 illustrates a typical application, and figure No. 14 details of the construction of the Coffin heater.

Of the open type heaters, the Worthington is the outstanding example, and practically all of this type applied so far are of this design, which consists of a combined pump and heater in one unit. Figure No. 15 shows the construction of the pump and heater, while figure No. 16 is a diagram giving the general layout of a typical application. This pump is steam-driven and consists of three cylinders arranged in tandem form with the three pistons on one common piston rod. The top cylinder is the steam unit, while the middle cylinder draws the cold water from the tank and delivers it to the exhaust steam chamber of the heater section in the form of a spray. This spray in condensing the exhaust steam absorbs the heat units and the mixture of the hot water and condensate is then forced into the boiler from the bottom or hot water cylinder. An oil separator is applied in the exhaust steam line when desired so as to prevent the carrying into the boiler by the feed water of the lubricating oil which may be in suspension in the exhaust steam.

The other closed type that is now attracting attention is the Dabeg, a successful Austrian design that has been applied on several American locomotives. In this, as in other open type heaters, the cold water is sprayed into the exhaust steam chamber, but instead of having a steam-driven pump it is actuated mechanically.

There are other instances of the application of special type and experimental heaters, but the foregoing covers the four principal ones now in service in Canada and the United States.

Passenger Service Costs Are Excessive

The cost of railway passenger service in the United States is out of all proportion to the revenues they produce, according to an analysis of operating expense accounts just issued by the Bureau of Railway Economics.

This study shows that in 1926 passenger service absorbed nearly 28 per cent of the total operating expenses of the railroads, but produced only about 20 per cent of the total revenues.

This estimate includes the revenues derived from the transportation of mail and express.

Excluding the revenues derived from mail and express, passenger service produced 16 per cent of the total revenues.

Practically one-fourth of the total expenses for maintenance of way and structures were related solely to passenger and allied services. About the same proportion of the total expenditures for the maintenance of equipment were apportioned exclusively to passenger service. Not quite one-half of all the traffic expenses last year went for passenger service, while something like one-quarter of rail line transportation expenses were apportioned to the passenger service.

Erie Railroad Buys Two More Oil-Electric Locomotives

The Erie Railroad has just ordered two 100-ton oil-electric locomotives for yard-switching service in the city of Akron, Ohio.

The two units now ordered for service in Akron, being of the 100 ton type, are larger and more powerful than the one purchased last year. The locomotives are a joint product of the General Electric Co., the American Locomotive Co., and the Ingersoll-Rand Company.

Railway and Locomotive Engineering

A Practical Journal of Motive Power,
Rolling Stock and Appliances

Published Monthly by
ANGUS SINCLAIR COMPANY
136 Liberty Street, New York
Chicago Office: 168 North Michigan Avenue
Telephone Rector 0746. Cable Address "Locong." N. Y.

Harry A. Kenney, Prest. and Man. Ed.
W. E. Symons, Associate Editor
J. Snowden Bell, Associate Editor
Thomas P. Kenney, Secretary

LONDON REPRESENTATIVE
The Locomotive Publishing Company, Ltd., 3 Amen Corner, Paternoster Row, London, E. C., England.

SUBSCRIPTION PRICE

$2.00 *per year,* $1.00 *for six months, postage paid in the United States, Canada and Mexico. For other parts of the world,* $2.50. *Single copies, 20 cents. Remit by Express Money Order, Draft, Post Office Order or Registered Letter.*

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Entered as second-class matter January 15, 1902, at the post office at New York, New York, under the Act of March 3, 1879.

Safety on Railways and the Highways

About a year ago there appeared in the columns of what we considered one of the leading magazines of the country, an article under the title of "Murder on the Rails," in which the author charged the railways with murdering innocent, helpless victims who had entrusted their lives to the carriers as passengers. According to the pseudo-engineer-author, the carriers could easily provide proper means of protection by purchasing a certain type of train control device, and by reading between the lines one could readily understand the motives that inspired that unbusinesslike attack on the railways generally. We countered with an editorial in our issue for September, 1926, refuting the false statements and fallacious theories embraced in the article in question and directed attention to the fact that travel on American railways was far safer than on the streets and highways.

The National Automobile Chamber of Commerce recently completed a survey which indicated that more people have been killed by automobiles alone in the United States than the American soldier dead in the World War. From Jan. 1, 1919 to Dec. 31, 1926, 137,017 persons were killed by automobiles, while the total deaths of the war in the American armed forces were 120,050. During the same period the injured in automobile accidents numbered 3,500,000.

Twenty-six percent of the killed and injured in these automobile accidents were children under 15 years of age. Last year the largest death toll ever recorded by automobiles has been estimated at 23,000 persons killed.

The persons killed and particularly that 26 per cent representing the children innocently playing on the streets or highways where they had both a legal and moral right to be is indeed appalling.

In view of this record, much of which is due to carelessness and the mania for speed, we are prompted to inquire if by any chance it is possible that those who were responsible for the unethical proceedure against the railways, as previously cited, have a patented device for sale calculated to minimize automobile accidents or fatalities. The record of slaughter could too be used in a selling campaign.

The safety of people on the highways should be provided for whatever the cost and it is high time that our law-making and other responsible bodies should take steps to that end.

Let those who are honestly and sincerely interested in this momentous question of the useless slaughter of 23,000 persons in a year or more than 60 per day, take as an example the standard of safety in travel on railways and strive to bring about conditions approaching that degree of safety in other lines of activity, and particularly in this inviting field for their efforts; automobile accidents and fatalities.

Increasing Use of the Telephone on Railways

There has been a marked increase in the use of the telephone in railway service where it is now being used not only in the control of trains but for the transmission of much other business of the railroads. Orders governing the movement of trains are now being transmitted by telephone instead of telegraph on a majority of the railroad mileage of the country, the telephone being considered more efficient and economical of the two systems.

The more extended use of the telephone in place of the telegraph has been particularly marked in the past seven years and has been due to the increase in both freight and passenger traffic, which required more prompt, accurate and complete information concerning many matters pertaining to operation and management of railways than was previously required.

However, the telegraph will always be used for the transmission of certain business, particularly for the transmission of the voluminous reports of freight and passenger operation to relieve the telephone lines of the heavy bulk traffic. As a result of the efforts of the telegraph and telephone sections of the American Railway Association at standardization of the thousands of miscellaneous messages handled daily over the telegraph wires between divisional and system headquarters, the work has been greatly simplified and fewer wires are required for them.

Many roads have installed telephones at signal bridges and sidings so that almost constant communication can be had by train crews with headquarters. Work and wrecking trains are being equipped with portable telephones so that first-hand information can be obtained direct from a train crew in less time and more satisfactorily than is possible with the telegraph.

Loud speakers have been installed in signal towers connected by wires with the dispatcher's office. By this means, signalmen in towers in terminal territory are kept informed with the movement of trains without being handicapped by a head-telephone when operating the switch levers.

In addition, some roads provide means whereby observation cars on limited trains are connected by telephone with the city telephone service, so that a passenger can communicate with any point in the city up to the time the train departs from the station.

The Motor Truck in Freight Service

Motor trucks appear to be handling most of the l. c. l. freight within a distance of approximately 40 miles, whereas railroads handle most of the carload freight within that distance as well as dominate the freight market for distances greater than 40 miles. These facts are brought out in a survey of the transportation situation existing between Columbus and selected Ohio cities.

This survey was conducted by the Bureau of Public Roads, Department of Agriculture. The report follows in part:

"In order to determine what proportion of the total tonnage of commodities moving between cities is hauled by motor truck, and also to develop the factors influencing the choice of motor truck or railroad, an analysis was made of the net tonnage hauled between Columbus and thirty-four Ohio cities by motor truck and rail lines.

"The cities selected are located from 7 to 134 highway miles from Columbus and were chosen to permit an analysis of the effect of length of haul upon the proportions of tonnage transferred by motor truck and railroad, respectively. . . .

"Motor truck net tonnage and railroad carload and less-than-carload tonnage data for an average month of 1925 were taken as the basis for this comparison.

Distance an Important Factor

"It is apparent that distance is an important factor in the amount of tonnage hauled by motor truck. Between Columbus and Akron, Cincinnati and Toledo, distances of over 100 miles, a very small part of the total tonnage is hauled by truck, while between Columbus and Grove City and between Columbus and Alton, distances of 8 and 9 miles, respectively, almost all of the tonnage is transported by motor truck.

"Although other factors besides length of haul influence the proportion of total tonnage hauled by motor truck and rail lines, respectively, and although the number of cities in each zone of haul is not large, there is clearly indicated the tendency for the proportion of motor truck tonnage to decrease with increase in distance.

"For hauls of less than 20 miles, 84.5 per cent of the total tonnage is transported by motor truck; between 20 and 39 miles, motor truck tonnage is 54.7 per cent of the total tonnage; and for the longer hauls, motor truck tonnage is 32, 24.2, and 2.3 per cent, respectively.

"As the percentage of motor truck tonnage decreases with increase in distance, both rail, carload and less-than-carload tonnage increase. No appreciable amount of less-than-carload tonnage is noted under 40 miles. Between 40 and 50 miles the less-than-carload tonnage is 5.6 per cent of the total and this percentage increases to 20.3 for distances of 100 miles or more.

Type of Commodity Important

"Among other factors controlling the proportion of total tonnage hauled by trucks are the type of commodities and rail facilities. An illustration of the former is indicated in the movement between Columbus and Johnstown. Although Johnstown is only 22 miles from Columbus by highway and 41 miles by railroad, 73.1 per cent of the tonnage is hauled by rail, practically all of which moves in carload lots.

"This high percentage of rail tonnage, considering the comparatively short highway mileage and the longer rail connection, is due to the type of commodity transported, 95.7 per cent of the total tonnage being gravel, sand and stone. These commodities cannot be economically hauled by motor truck for this distance, as is indicated by the fact that the average length of haul for trucks hauling gravel, sand and stone in Ohio is only 10 miles. . . ."

The Vacuum Brake on the Indian Railways

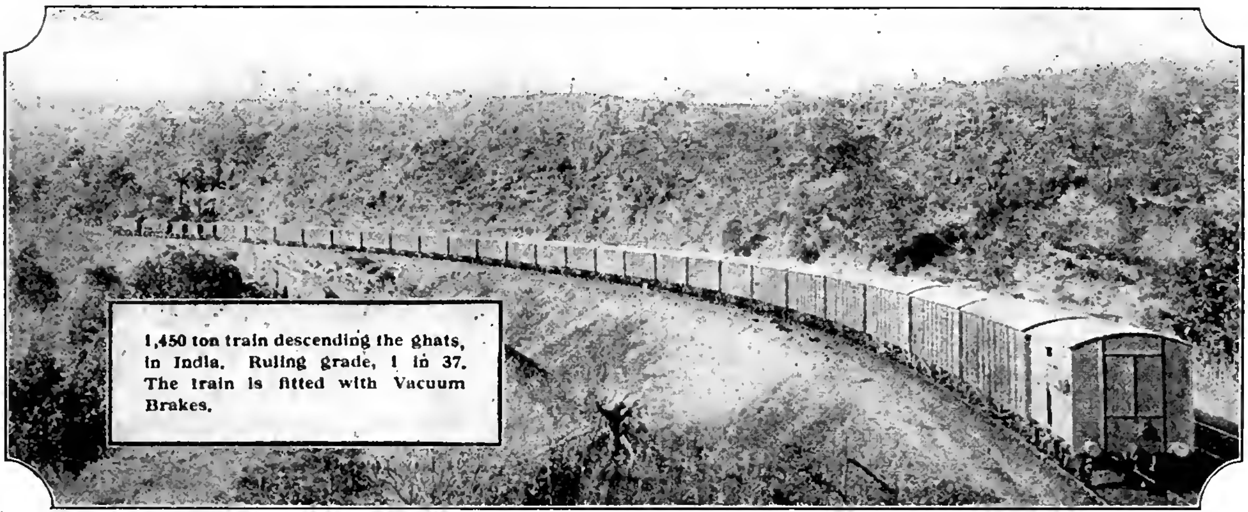
It is remarkable how the authorities in India cling to the hope that they will eventually succeed in getting the vacuum brake to operate satisfactorily on the rapidly increasing length of freight trains there. Things are now approaching a crisis for the Railway Board, stirred by a certain amount of public interest, have recently issued a "half-hearted" order that the power brakes on all freight equipment must be maintained in good working order and all vehicles offered for interchange at junction yards must have the brake apparatus in an operative condition. To American railroad men this will appear to be a somewhat illogical means of securing proper operation; the fact is that grave doubts exist in the official minds as to the possibility of operating the vacuum brake over long freight trains satisfactorily, and there is considerable hesitation in issuing orders which might be considered as drastic. What the authorities really want is complete operation on all trains, passenger and freight.

By way of encouraging an attempt at solution of the problem, the Railway Board ordered some trials to be made last year on the Eastern Bengal State system with long freight trains fully braked, but the report was of such an indecisive character that it increased the doubts rather than decreased them. Anyway, something had to be done, and last fall the East Indian State system was recommended to attempt complete operation, with the result that a period of semi-chaotic operations has been experienced, unheard of consumption of rubber details, terrible delays in traffic, and considerably enhanced coal consumption. The situation is so bad that there are indications of a general abandonment of the brake for freight trains and return to the old methods of control with weighted brake-vans "pro tem," until some more satisfactory means can be evolved or a change made to air-operated apparatus.

It is remarkable that this position was prophesied by our London contemporary, the "Engineer" as far back as 1878, so says a writer in a recent issue of that journal. The vacuum brake was accepted by the Government of the day as sufficiently good for the time, and adopted for general application to the passenger trains, to be eventually extended to the freight trains without any further investigations as to its shortcomings. The new rolling stock has been fitted with brake apparatus for some twenty years past, but never operated, as the continuous piping did not exist throughout the trains nor were all locomotives fitted with ejectors and gear for operating it. During this long period of inaction, the apparatus has considerably deteriorated and in fact become useless so that large replacement is necessary to get the brakes in working order. This re-conditioning has now been going on for some four or five years preliminary to the Railway Board's action dating from April 1st last, when the order mentioned came into force.

That very determined efforts are being made is certain and the effort will not be abandoned until every suggestion has been tried. To assist the train staffs in getting a through vacuum of some sort, exhaustion down to six inches has been adopted, but, as the engineers point out, such a pressure in the train pipe is of no service, when the brake blocks are pulled on to the wheels the effect is nil—it only "tickles" them.

Meantime, the advocates are strongly in favor of more drastic remedies against leaky apparatus, etc.; they suggest all joints in the pipes should be welded up, the rubber hose connections more substantially attached to the metal "nipples," etc.—all, of course, to more or less "camouflage" the real trouble, which is, the difficulty of maintaining a high vacuum throughout long trains, and also to secure quick release after an application. This "throwing of red herrings" is very common practice with the advocates of the vacuum brake, and we reproduce an advertising stunt by one of the interested manufacturers, which will illustrate our meaning. The photograph shows a long freight train descending one of the Ghant inclines approaching Bombay, and attention is called to the fact that the train is being controlled by the automatic vacuum brake, but nothing is said of the *three* heavily-weighted 20-tons brake-vans which can be seen at the front of the train, and which have to be retained owing to the risks which would be incurred if reliance were placed implicitly on the vacuum apparatus under the cars.



Freight Train on Grade Controlled by Vacuum Brakes and Brake Vans

It is stated that this attempt to secure general operation of the brakes on freight trains of the broad-gauge railways has cost a vast amount of money, and so far as can be seen no benefit has been secured in the way of reduction in dead weight hauled, increased speed of operation, etc., for it has been found impossible to dispense with the heavily-weighted brake-vans provided at the rear of trains to secure safety, owing to the liability of broken couplings, the present screw devices being admittedly weak and unreliable.

Speeding up of the trains has not developed, owing to the want of automatic mechanical couplers, and the loss of time in attaching and detaching vehicles with the screw device mentioned continues. It has been ascertained that to couple, with arrangements in the best of condition, the average time taken to couple and uncouple a train of 6 vehicles is 30 minutes. With mechanical or M. C. B. type couplers, the connection would be made practically instantaneous and the only work necessary would be to couple up the brake, which can be performed in 10 minutes.

In the report of the trials on the Eastern Bengal Railway referred to, attention is called to this phase of the situation, and there is no doubt that if the Indian authorities desire to secure the advantages they should with the operation of continuous power brakes they must come to some decision regarding couplers. So far, we understand, the extended equipment of stock with the "Willison" Coupler, introduced by the National Malleable Castings Co., of Cleveland, Ohio, through their British representatives, Messrs. Cammell Laird & Co. has been very successful. Tests are now being made with new cars constructed for central draft gear and couplings to ascertain the cost of a change and the modifications in construction which will be necessary to the rolling stock to make it adaptable to the new state of affairs.

Tank Locomotives Here and Abroad

By Arthur Curran

Reference in the June, 1927, issue of Railway and Locomotive Engineering to the record-breaking locomotives of the Great Western Railway suggests the possibility that representative examples of at least two of the classes might be of interest at this time.

As the dimensions of the 4-2-2 class were given in the issue mentioned above, it is not necessary to repeat them here; but merely to give them added value by presenting a photograph of the "Wellington," which very clearly illustrates the features of design referred to in that issue.

What was known a generation ago as the "single," was very much overrated in Great Britain, where most of the many small railways used it. Touted by its advocates as the best possible express type, it really did little, on the majority of roads, to justify the extravagant claims made in its behalf.

I call to mind, in particular, a class of "singles" which ran for many years on one of the lines north of London. In spite of all that was said for them, they rarely exceeded 60 m.p.h., and actually did most of their work at 50 m.p.h. or less!

Even poorer figures could be quoted for most of the other "singles" in Britain, though occasionally one of them managed to attract attention by a run of rather unusual merit.

In America, the Reading experimented with the type, but found it deficient in tractive power even with light loads.

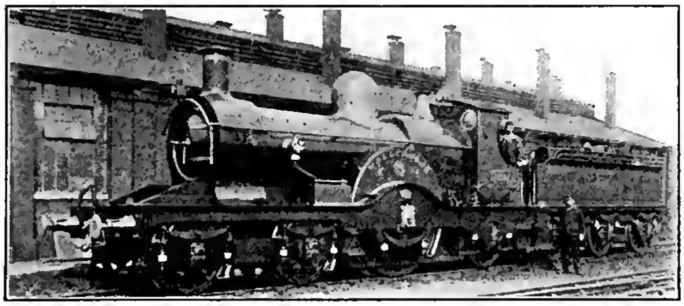
No doubt, the type was tried in various other countries with the same result; though, when once purchased, many must have been kept in service for some unknown reason.

Curiously enough, the Great Western Railway—which did no boasting at all—got some surprisingly fine results from the type. Skillful designing and correct assignment of the engines helped in this achievement. No attempt was made to use the 4-2-2 engines on hilly divisions or on trains which, by reason of their weight or the number of their scheduled stops, were unsuitable tasks for them.

On the "Flying Dutchman" and similar trains they shone from every point of view. On mail trains—postal cars only—they did some very fine work. A great deal of mail matter was unloaded from ocean steamers at Plymouth, most of which was addressed to London. As the steamers arrived at odd times—frequently late—it was necessary to provide a "path" for mail trains at short notice and run them at a hair-raising speed. The new line via Westbury was not in use at the time; and it was, therefore, necessary to route these "hair-curlers" via Wootton-Bassett, over the old main line, crowded with traffic to and from Bristol and South Wales industrial cities.

The Great Western Railway said very little about these trains, which would have passed the majority of British expresses as though the latter were standing still! But the experts of those days spoke of them with profound respect; as well they might, since, on the Great Western Railway, mail is moved as mail, and not as freight. As a job of dispatching it is really classic, and would make a fascinating story of resourcefulness and transcendent ability under the most trying circumstances.

The other design, which exerted considerable influence upon the motive power tendencies of the Great Western Railway was represented by the "Atbara" Class. One of the best known engines of this class was "Baden Powell," a photograph of which is presented herewith. The dimensions were as follows:



Locomotive Wellington of the Great Western Railway of England

Cylinders 18 x 26 inches, drivers 80 inches; weight, without tender, 115,440 lbs. The boiler was 54 inches in diameter with a steam pressure of 180 lbs. per square inch, and the heating surface was 1,663 square feet. Grate area 21.5 square feet.

It will be noted that this class had a Belpaire firebox which was noticeably higher than the top line of the boiler barrel. This gave the class a distinctive and rather massive appearance. At this point, it may be mentioned that this style of boiler must have been a success, as it was applied to at least some of the 4-2-2 engines in their later years of service.

When, however, the engines of the "Atbara" Class required heavy repairs, a coned boiler barrel was substituted for the straight barrel, as shown in the original design. As thus equipped, the "Atbaras" went into the "Flower" Class, where they are to this day. This "Flower" Class now includes more than 70 engines, consisting of new ones named for flowers and older ones rebuilt to an extent which justified their rating in this group. Their tractive effort—17,790 lbs.—is the same as that of the "City" Class, though their weight is somewhat less. When the "Atbaras" entered the "Flower" Class, their working pressure was raised to 200 lbs. per square inch. For their size, they certainly are about as smart as anyone could wish.

Locomotive "Baden Powell" of the Great Western Railway of England

Accounts of the Great Western Railway very naturally say a great deal about its chief services; these covering the routes to Birmingham, those using the old main line to Bristol and a somewhat different route to South Wales, and, finally, the traffic to and from Plymouth and Penzance, via the newer line through Westbury. Not so much is said, however, about the "cross-country" services, many of which are of considerable importance and involve rather smart running. These are not branch line runs, but are through services between cities of considerable size and consequence as centers of traffic. The passenger equipment is "bogie stock" and the engines are of the "Flower" and other suitable classes.

The network of lines which intersect the main routes of the Great Western Railway present some very interesting problems in running which give both engines and their crews plenty of tests. The English engineman is something of an artist; and, according to all accounts, he needs to be! The "uphill and down dale" nature of the country, the speed restrictions at various points, and the necessity to know the class of engine that he is running as well as he knows his own name give him plenty to think about.

Perhaps as interesting as anything else, however, is the fact that the crews on the Great Western Railway like their engines and hold a high opinion of the men who designed them. I think it will be admitted that this makes for good "team-work" and a high degree of efficiency.

Eastern Engineers Get Increase in Pay

On August 3 most of the Eastern railroads agreed to a flat 7½ per cent increase in the individual rates of pay of their locomotive engineers. The agreement was made by John G. Walber, Vice-President, New York Central Lines, as chairman of the Conference Committee representing the railroads in question, and by A. Johnston, Grand Chief Engineer of the Brotherhood of Locomotive Engineers. The good offices of the Board of Mediation were invoked on May 26, 1927.

Approximately 30,000 engineers are involved. The increase in wages will amount to approximately 6 million dollars. This settlement gives to the engineers the same proportionate addition to their rates of pay which have already been granted by arbitration to conductors and trainmen, and by agreement to firemen.

In passenger service the rates of pay will vary from $6.62 to $7.48 per day (100 miles, or 8 hours). The minimum guarantee for engineers in passenger service is raised from $7 to $7.53 for each day's service performed.

In freight service the rates of pay will vary from 7.35c. to 9.42c. per mile. The daily rate is 100 times the mileage rate. Engineers engaged in local or way freight service will receive 52c. per 100 miles additional.

In yard service the rate of pay will vary from $7.22 to $8.64 per day.

Any existing rates of pay in excess of standard rates will be increased the same amount of money as provided for the standard rate.

It has been estimated that the agreement will increase the payrolls about $6,500,000 annually.

The increase is to take effect as from August 1, and the contract is for one year; with a proviso that it continue thereafter if neither party gives 30 days' notice of the desire to bring the agreement to an end.

The Wheeling & Lake Eric, the Delaware & Hudson, the Pere Marquette, the Ann Arbor and the Boston & Maine did not participate in the conferences and their enginemen are not affected.

Automatic Air Brakes on American Railways

A Prime Factor in Present High Standards

By W. E. Symons

It is a long journey from the crude little structure of 1828, when the first steam railway train appeared to the present time, but in this span is embodied the history of the numerous obstacles, and various stages of development represented in the modern palaces on wheels today.

Great credit is due to those early pioneers who through their indomitable will, untiring energy, inventive genius, mechanical skill and loyalty to the cause, laid the foundations of the superior transportation system which we enjoy today. While railway men, have, as a rule, been found in the front ranks of those to whom the principal credit for this wonderful achievement is due, it must be borne in mind that the manufacturers of railway supplies and special devices contributed largely to the final results obtained. In some instances the valuable assistance by manufacturers was not given the credit and cordial welcome it deserved.

From 1886 to 1892 the present Santa Fe System, as we now know it, did not exist. There was the Santa Fe extending from Kansas City to El Paso, Texas, with a branch from La Junta to Denver, Colo.

From Albuquerque, New Mexico to Mojave, California, was the Atlantic and Pacific Railway, 821 miles; while at Barstow connections were made with the California Southern Railway with 142 miles to Los Angeles and 268 miles to San Diego. At Mojave connection was made with the Southern Pacific for San Francisco, 382 miles.

The writer was in 1886 to 1889 in the service of the Atlantic and Pacific Railway, first as machinist, then as locomotive engineer, stationed at Needles, California. In the latter capacity we handled both freight and passenger trains over the mountains of western Arizona and the Mojave desert in California, under conditions which were indelibly impressed on one's memory at the time, and form the basis for the information at this time as to actual conditions of power brakes and the important part played by the brake people in remedying the unsatisfactory and at times decidedly dangerous conditions then existing in train operation.

It might be well to mention that the years of 1887 and 1888 were known as California boom years and during much of that period, the Santa Fe made up and moved daily several sections of their west bound passenger trains at Kansas City, delivering them to the Atlantic and Pacific at Albuquerque, New Mex., which line in turn delivered most of these to the California Southern Railway at Barstow, the remainder being delivered to the Southern Pacific at Mojave for San Francisco.

Thus it will be seen that the palaces on wheels of today that roll out of Polk street station in Chicago and more unbroken under one continual management to their destination on Pacific coast were abbreviated affairs moving under three different managements in reaching the coast.

From the foregoing, it may be inferred that in addition to the comparatively undeveloped condition or standard of equipment and its principal accessories, the lack of facilities and methods for its proper maintenance at the time, that the three managements under which the trains moved from the Missouri River to the Pacific coast were more than willing to shift the responsibility for complaints to one of the other two, than to take hold of them in a businesslike and constructive way with the view of eliminating them, and improving operation.

It therefore followed that an engineer handling these trains, particularly through the mountainous sections of western Arizona, sometimes found himself in charge of a train without proper braking power to handle it, and a disposition on the part of officers of road to not only treat lightly, if not entirely ignore, complaints made as to potential elements of danger, that might result in the loss of life and property. Sometimes he would be censured or criticized for what was termed officious meddling in matters in which he was not concerned.

It was the cumulative effect of numerous incidents and near accidents that resulted in bringing about a sudden change in this whole question of adequate brakes and their proper maintenance in the Rocky Mountain district.

These passenger trains during the above mentioned boom period were usually made up for movement west of Albuquerque over the Atlantic and Pacific Railway, with 10 to 12 cars using a helper or double header engine on grades. At Williams, Arizona, which was at the top of Bill Williams mountain, there commenced the descent to the Colorado river. The trains were frequently cut in two, giving the express mail and coaches to one engine and the Pullman cars with one coach to another engine and crew. This splitting up resulted in bringing about the reforms referred to later. The writer had handled at different times these trains unbroken but with a helper on ascending grades through from Williams to Barstow and Mojave 439 miles, although with the small air pumps of that period it was often difficult to hold trains on the descending grades of 1½ per cent and more. Equally as good, or slightly better results had been secured when handling the head section of the split up trains, which had no Pullman cars.

Difficulty had been experienced in handling the rear end or Pullman section of the split up train down the mountain, and as no one knew the real cause, it came to be rather common talk that it required a first class engineer to handle a train of Pullman sleepers down a mountain grade, but that most any engineer could handle a train made up of coaches, mail and express cars.

In this atmosphere and with two or three rather nasty near run-aways of the Pullman or rear end sections in mind, the writer, following a continuous double from Peach Springs to Mojave and return to Williams 791 miles was given the rear end of a split up train consisting of seven cars, 6 sleeping cars and one coach, with a combined admonition and order from a division officer to "take this train safely down the mountain, and show this bunch it is only a question of competency. Just knowing how to do the trick, and nothing more."

To this advance endorsement, I did not subscribe and started out with what soon proved to be well grounded misgivings as to the ease with which the trick might be turned.

In fact the train actually ran away, and it was almost miraculous that it did not leave the rails and roll down the mountain side. Equally as miraculous was the fact that this run-away train remained on the rails until finally brought to a stop about one-half mile west of a station, where I had a positive meeting order with an east bound train, that stopped and backed up in time to avoid a nasty head on collision.

When finally stopped I took stock as to conditions as follows:

A—All driving wheel tires slipped, from excessive brake shoe application and had to be re-set to gauge before proceeding.

B—Cylinders and packing, valves and seats, badly burned and cut on account engine in reverse motions all the way down the mountain, about 16 miles.

C—Two sets of tender truck wheels slid flat.

D—A badly scared crew and passengers, including those on the train that averted a collosion only by quickly backing up from the run-away.

On going back to examine the wheels of the train which I expected to find all burned up as it were, I was surprised to find some wheels cool, others warm but not hot, except the railway companies coach on head of the train, the wheels of which were very hot. At first blush I thought some one through malicious mischief had turned an angle cock on the train, but examination showed this to be untrue, and after a while a trial of the brakes showed that they all functioned, but that the piston travel was such that in full application the brake shoes only came up easily against the tread of the wheels, and here was the "Nigger in the wood pile."

The Pullman people had discovered, strange as it may appear, that brake shoes lasted longer handing idly in the air than when properly applied to the face of the wheels to absorb energy on descending grades, and also that the wheels lasted longer. They were evidently perfectly willing that the railway company not only haul these cars in level country and up the mountain side, but then do practically all the braking with railroad units on the descending grades of the mountains. Consequently, when these sleeping car units were detached for movement alone, they were dangerously deficient in braking power on heavy grades, hence this and other somewhat similar run-aways. On arrival at terminal headquarters I was not only required to amplify my telegraphic reports as to cause of this accident by a long written report and rigid cross examination, in which it was intimated to me that as these trains had been moved over the Raton and Glorietta mountains safely, where the grades were heavier than on the A. & P. Railway, that the railway company was considering the advisability of requesting the Santa Fe Railroad to loan them some of their competent engineers to come over there (on the A. & P.) and show us how to do the job right.

To my suggestion that we had little or no trouble with these trains with an equal number of railroad companies cars ahead to hold them on descending grades, and that was the actual make up of trains crossing the Raton and Glorietta mountains, which accounted for apparent freedom from run-aways, met with slight consideration, and it began to look as though myself and possibly some other engineers might change our place of business.

I wrote to the Westinghouse Air Brake Company, requesting sectional models of brake and triple valves, and asked if they would send a man to explain the models and lecture to the engineers on the use of air brakes in general, it being my idea that if an expert came I would then tell him in confidence about the Pullman brakes, which information I would not risk in a letter. In about two weeks I received reply that the models would be shipped at once and an expert would come to us at an early date.

Some two weeks later while the writer was trying to snatch off forty winks of sleep in the back room of a cheap shack at Barstow, Calif., he was aroused by violent pounding on the door by a man who, when he gained entrance, said: "I am Harry Fraser of San Francisco, where I represent the Westinghouse Air Brake Company, and have here a letter from Mr. George Westinghouse to come here at once and look you up, and not leave until your every need in our line is taken care of."

Well, we journeyed to the headquarters at Needles, Mr. Fraser riding with me on the engine most of the way, where after introductions the writer was first censored for having committed the great crime of writing direct to the brake company, and then solemnly warned to never, no never, do such a thing again.

When Mr. Fraser had convinced them (the division officers) about the miserably dangerous conditions there existing, the whole antiquated, inefficient operations were abandoned, for what was then quite up-to-date methods. The piston travel on all Pullman and, in fact, all foreign passenger equipment was properly adjusted at Albuquerque, Barstow, Mojave, and other points, with the result that there was no more trouble with runaway passenger trains and a vast improvement in handling mixed and freight trains. This led to a general improvement in both equipment units and the accessories and the facilities for maintenance. Thus, the manufacturers of a most important part of railway equipment became a potent factor in raising the standard of service and improving economic conditions from operation of a most highly valuable character, and that without a penny expense to the railway company.

Again a few years later, while a division officer at Raton, New Mexico, where grades of 2½ per cent and more must be negotiated in crossing the Raton mountains, there arose quite an epidemic of hot, slid flat and broken wheels under freight cars, several of the broken wheels causing derailments or wrecks of no small consequence. It was observed that a preponderance of these wheel failures were of a certain type and make of wheel used under a large series of new cars then coming on the line from the car builders, and also extensively used for replacements under cars coming from the shops following heavy repairs.

These were a double plate wheel, one plate of which would crack, due to unequal expansion when heated by constant brake application on descending mountain grades, and aside from the number that actually broke or failed a great many cars were marked out of service by car inspectors on detecting the cracked plates in hot wheels at the foot of the mountain.

The number of failures reported brought out from the East representatives of the car and wheel manufacturers. Much to their pleasure and the writer's chagrin, the big cracks in the wheel plates reported were not in evidence on inspection, for the simple reason that in cooling the contracting effect had closed the cracks so completely that even with a strong glass it was almost impossible to find them.

My case seemed to have fallen down, although I protested that I had personally seen these cracks in wheel plates. I at once met with the rejoinder, "Well, we are here to inspect them. Show them to us," and was admonished to look more after the defective brakes on freight cars, instead of seeing so many imaginary cracks in wheel plates.

Recalling my former experience with the brake problem in California, I sent direct for the Westinghouse representative, Mr. Ben Johnson, and on his arrival explained the whole thing, and we jointly mapped out a plan of procedure to clean up the erroneous conclusions of the preceding jury of experts and officials.

First, we secured a camera and photographed wheels with cracked plates from heating due to long continuous brake applications on descending grades. We then took the condemned wheels that the jury of experts and officials had pronounced O. K. and ordered them put back in service and heated to a temperature corresponding to that registered from brake shoe applications, and the original cracks reappeared. They were of a size that would receive a knife blade or lead pencil point. These we photographed with wheel numbers, etc., all of which proved as reported and that wheel failures were due to two causes: (a) faulty design of wheel, and (b) lack of proper facilities to maintain brakes, thus imposing extra duty on brakes of new and rebuilt cars, in order to hold trains on descending mountain grades, and that the fault was not with the brakes, but rather to their lack of maintenance and proper use.

As a result of this investigation and largely through the aid of the Westinghouse representative, what was then considered a most elaborate and expensive system of yard piping with air, repair tracks, shops, test racks, etc., were installed. These were the foundation of the present effective facilities for maintaining power brakes on railway trains in the Rocky Mountain district.

Defective wheels were replaced with a better design, budgets were approved for ample forces to put the brakes on all cars in good operating condition prior to moving on the mountain district, with the result that braking was then uniform throughout the train, each unit or car sharing its own proportion of the load, while runaway trains, slid flat and broken wheels from excessive brake application became rare things as the reasons assigned for delayed service.

In each of the foregoing instances, which were 33 and 40 years ago, the equipment as a whole and its standard of maintenance and service were both raised to new levels, which led to improved designs and greater efficiency in operation of the complete transportation unit. The credit was due largely to the cheerful co-operation and valuable aid rendered by the manufacturers of the power brakes, at that time coming into general use on freight trains.

Development in Air Transport

Not Expected to Materially Affect Present Transportation Agencies

The application of the aeroplane to general transportation has not had the attention in America that it has received abroad, where well established air lines have been in operation for years, but much preliminary work and planning has been advanced toward the establishment of air lines in this country.

Since his memorable flight, Col. Lindbergh has been engaged in a tour of the country during which he will visit the principal cities with the object of arousing public interest and securing support calculated to provide proper facilities and legislation essential to development of aerial navigation, for either peace time or war conditions.

From available data it is evident that our leading men in the fields of finance, commerce and transportation have been giving the subject of aerial transportation more attention than is generally supposed, and a brief review of some of the more important contemplated improvements in facilities such as air ports or flying fields may be of interest. These it will be observed involve estimated expenditures of many millions of dollars, and it may be safely predicted that as a result of present enthusiasm on this subject that the expenses authorized or incurred during the next two or three years may easily reach the billion mark in this country alone, while the development abroad will no doubt be on equally as broad a scale.

A few score years ago, when measured by the transportation yardstick provided, it was a tremendous distance across the continent. It took 60 days to cross only seventy-five years ago, and the trip then was made partly by canal boat, partly by stage coaches, and partly on horseback, and it was a difficult, dangerous trip, and a fatiguing one. Then came the railroad era, and with its perfection along about the first of this century, the distance, this sixty days was cut down to about ninety hours and the effect on business, of course, was tremendous.

Now, however we have a new transportation yardstick and the three or four days is reduced to thirty hours. So that, measured by the transportation yardstick of aircraft, we have a country that is thirty hours wide and ten hours broad. If one thinks what that is going to mean in business, he can see what tremendous possibilities are ahead of us when our transportation problems in the United States are thus reduced by aircraft.

It is curious that we were slow in this country after the war to see these possibilities. Perhaps in Europe they were better educated by the war, which was close to them, as to what aircraft could do. So the spread of aircraft came first in Europe. The first air lines began between London and Paris, where they converted some of the army planes into passenger planes, very uncomfortable ones, but they carried a number of delegates across to the Versailles Peace Conference. Out of the military use for transportation purposes grew the great network of air lines in Europe, and today, one can travel from London to practically any capital in Europe over air lines on regular schedules, and run in a most reliable fashion.

Now, when it comes to the commercial side of aviation, what is known as air transport abroad, those are in operation on fixed schedules over regular routes, and they are increasing quite rapidly. At the present time, commercial air transport operations are something better than 20,000 miles a day in this country. That means planes are flying this distance on schedules that are being kept with a regularity comparable with that of any other means of transportation. It is true they are affected by weather. But every means of transportation is affected to some extent by weather.

There is no way to tell anybody what aviation is about unless you try it yourself. We have today planes that are remarkable for their comfort, for their safety, for their reliability. The Fokker three-engine plane is a beautiful plane. Byrd demonstrated its reliability in his flight to the North Pole and back. The Philadelphia Rapid Transit Company operated for four months between Philadelphia and Washington during the sesquicentennial and carried over 3,700 passengers with absolute safety. The vice-president of the company said they have demonstrated to their own satisfaction and to the satisfaction of any reasonable person who will study their records, that air transportation can be operated with multi-engined equipment of that character with sufficient safety, dependability and reliability to justify its operation anywhere.

There have been 50,000,000 miles flown since the war on regular scheduled air lines carrying passengers or mail or goods throughout the world. Over a quarter of a million passengers have been carried on those lines, and thousands of tons of mail and goods. There are a few lines that are making money today. There is one line down in Central America which paid 10 per cent dividends every year until last year, when they paid 12 per cent. There is a line out west that due to a very favorable mail contract is doing very well financially. There are other lines that are supporting themselves.

Safety in Air Travel

As in all things new the public must of necessity be convinced of its merits and safety, and the same or even a more convincing propaganda is required as was used to get people to leave the ox-cart or stage coach to travel in a railway train at a speed of 10 to 15 miles per hour. This feature is now occupying much of the time of the publicity or advertising officers of foreign lines, and will no doubt draw heavily on those who develop the lines in this country.

It is claimed abroad that travel by air is speedier and safer than by rail. The arguments in Germany in particular by one of the leading air lines is that in 1926 there was only one fatal accident to a passenger, and this was due to the loss of an airplane in a storm. This record was achieved despite a total of more than 6,000,000 kilometers, flown during the year by German commercial planes and 56,628 passengers safely transported. Against this record of safe travel it is pointed out that on German Railways for the year 1925 there were 628 accidents, number persons killed or injured 944, while in Berlin the street railway lines reported 140 persons killed and 3,021 injured.

There is no such thing as absolute safety. Nothing is absolutely safe; travel by air will never be absolutely safe. Neither will travel by rail or motor car. All forms of transportation involve hazard. The whole question that the public want to know is not is it absolutely safe, which they know is unattainable, but whether the advantages of this form of transportation obviously outweigh the hazards which it introduces. The railroad train was a thousand times more dangerous than the canal boat. Yet people don't travel by canal boat any more, and the aircraft, while it introduces a new form of hazard over any other form of transportation, at the same time gets away from a lot of hazards which our present forms of transportation involve.

Aerial Navigation Abroad Constitutes a Net Work of Lines

The progress abroad has been quite recently reviewed by Mr. T. R. Ybarra in which and among other important facts the following data is presented. The system of air communications in Europe is today so complete and so intricate that it rivals the railroad. Enormous strides forward have been made in the last eight years in the development of aircraft as vehicles for transporting passengers and freight. Of all European commercial air lines the most popular is still that between London and Paris. A bare seven years ago it was an adventure to fly between these two cities, and Americans doing it felt like heroes when they told about it on returning home. But now it is commonplace.

Whereas at the close of the war only one plane a day flew between the English and French capitals in each direction, there are now half a dozen operated by an English and a French company. These planes are the last word in speed and comfort, and despite some serious accidents which have marred the record of the London-Paris service, those operating it never tire in pointing out that air travel is really safer than travel by rail.

London is also linked by direct air lines with Brussels, Amsterdam, Rotterdam and Cologne on the European Continent. But when it comes to the other cities of Britain, there is still a complete lack of aerial transportation facilities. Though eight years have elapsed since commercial aviation was born, no plane flies regularly between London and Manchester, Birmingham, Liverpool, Edinburgh or the rest of Britain's great centers. However, things are quite different in Germany, especially, air lines have multiplied to such an extent within the last few years that air travel there has already dropped from the domain of the sensational and become something almost if not quite humdrum. For a German business man to fly from Berlin to any one of a score of other German cities is now scarcely worth comment; for him to leap by airplane in a few hours to any one of a dozen foreign capitals has become a commonplace of German business routine.

The kernel of Germany's air traffic is the Luft Hansa, or air league the greatest of all existing commercial aviation concerns. It was formed in 1925 by the amalgamation of several companies which were pioneers in the aerial field. The air lines of the Luft Hansa now extend all over Germany so that one may fly either directly or by means of transferring between practically any two German cities of importance. In addition, it operates either alone or in conjunction with aerial navigation companies of other countries a series of international air services which comprise some of the longest and most important in existence.

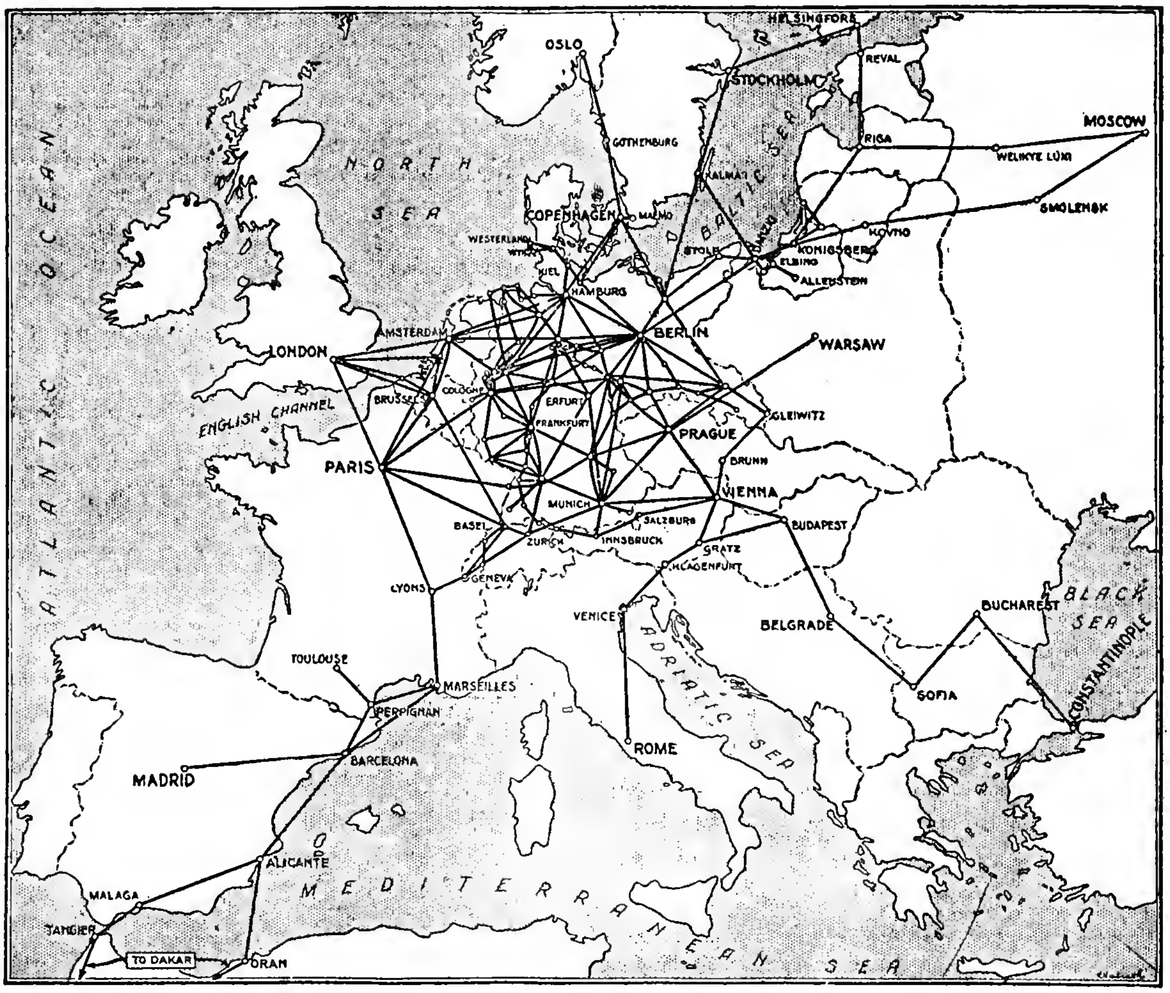
The three international lines operated by the Luft Hansa without the cooperation of any other concern are those between Berlin and Zurich in Switzerland; between Stettin, in North Germany, and Stockholm, the capital of Sweden, by way of the Swedish port of Kalmar, and between Amsterdam, in Holland and Basle, in Switzerland, via the German cities of Dusseldorf, Cologne, Frankfort-on-the-Main and Munich.

The Luft Hansa now has a fleet of 120 airplanes in commission for its manifold air service. During the first post-war years the restriction imposed upon Germany aerial development by the Versailles Treaty enabled German airplanes construction to employ only single-motor machines for air traffic. This greatly handicapped them in competing with the pioneers of commercial aviation. But last year this restriction on the Germans was removed and they set to work to equip their air lines with some of the newest type of machines having more than one motor. This and other factors have enabled Germany to forge ahead in aerial development at a rate surpassing that of any other country in the world. In 1919 German commercial air lines carried a total of 2,042 passengers but this number had risen by steady steps to 13,422 in 1924. In 1925 it suddenly leaped to the astonishing total of 55,185, and in 1926 to 56,268.

During the same period the number of kilometers flown daily by German commercial planes rose from 3,060 in 1920 to 37,222 in 1926. The amount of freight carried on German air lines was 5 tons in 1920 and 641 in 1926. The mail matter transported rose from 6 tons in 1920 to 301 tons in 1926.

In France the Air Union, a French company, maintains a regular airplane passenger service between Paris and Marseilles via Lyons. At Lyons connection is made with planes of the same company, flying to Geneva, Switzerland. Another French company operates an air service between Paris and Amsterdam via Brussels.

One of the longest of the great international air routes is operated by a French company with headquarters at Prague. It is from Paris via Strasbourg, Nuremberg and Prague to Vienna and thence, after passengers have transferred to other planes to Belgrade, Yugoslavia; Sofia, Bulgaria, and Constantinople, Turkey. The French also are pioneers in the domain of inter-continental aviation. A company is already running a regular airplane service between Paris and Casablanca in Northern Africa via Toulouse and Perpignan, Barcelona, Ancante and Malaga, Spain, and Tangiers and Rabat, Morocco. The planes on this route cover a distance of about 1,150 miles between Paris and Casablanca in thirtteen to fourteen hours. Companies also operate lines between Marseilles and Oran in Algeria via Alcante, Spain, and between Marseilles and Dakar, Africa, via Casablanca. There is also a company air line between Antibes on the French Riviera and Tunis, Northern Africa.



Courtesy of New York Times.

Map Showing Air Routes in Europe

The Belgians have established an air route between Antwerp and several places in Belgian West Africa.

Five lines radiate from London, England, either directly or through connection reaching Oslo, Norway; Helsingfors, Finland; Moscow, Russia; Constantinople, Turkey; Rome, Italy; Warsaw, Poland; Madrid, Spain; Oran and Tangier, Africa; while there is not a line north from London to the thickly settled populous trade centers of Birmingham, Liverpool, Edinburgh or Glasgow, Scotland; or Belfast, Ireland. Just why air lines can be operated to some of the far away points, while none are provided in what appears to us a more populous and inviting field will, in absence of explanations appear rather strange, although there is no doubt a reason for it.

Some may reach the conclusion that the foregoing really means the passing of our steam railways, and to those who may yield to this fallacious theory we must point out that the foregoing development together with additional air lines are absolutely essential as auxiliaries as it were to railways, and that the combined capacity of all transportation agencies will be taxed to meet demands imposed on them during the next 25 to 50 years.

Recently the operating vice-president of one of the largest railway systems of the world had this to say with respect to the future of steam railways:

"We are still in the infancy of railroading. Their century of development has not even begun to exhaust their possibilities nor do I think we are in any danger of passing into an era which they will yield the first place of importance to any other transportation agency.

"No one could be more impressed than I am with Lindbergh's wonderful feat, or readier to recognize that he and other pioneer fliers have opened a new chapter in transportation over land and sea. Similarly, the first successful motor car of twenty-five or thirty years ago opened a new chapter although few measured its importance at the time.

"To me the outstanding fact is this: After more than a quarter of a century of motor cars, and their development beyond the wildest dreams of the original producers, our railroads are today carrying far more freight and far more passengers than they carried before we had any motor cars.

"In a similar way when air transport becomes an everyday fact, whether that be a dozen years or twenty years from now, I am equally sure that the railroad will be carrying still more freight and still more passengers than at present."

Limited Cut-Off Increases Capacity and Economy of Locomotives[*]

By H. J. VINCENT, Chief Consulting Engineer of the Franklin Railway Supply Company, New York

To successfully operate a road on the theory of the maximum ton miles per train hour, locomotives must be rated at the power which they will deliver at the maximum operating speed, then be furnished with sufficient starting capacity to get the train under way, when confronted with the most adverse conditions.

This combination of requirements can only be satisfactorily met when a boiler and grate having the capacity to furnish steam economically and cylinders which will deliver a horsepower for the minimum expenditure of steam, are provided.

The locomotive of the future will very likely use high steam pressure, probably from 400 to 600 pounds, and be provided with a water tube firebox. That development is, however, still somewhat in the future. We are dealing with present necessities which require keeping the pressure within the capacity of a stayed water surface. This pressure may be as much as 300 pounds, but the best present practice seems to limit it to from 250 to 270 pounds.

For the boiler to produce the steam most economically, the grate area must be of sufficient size to obtain the rated horsepower and a certain percentage of overload without necessitating a high combustion rate. From 60 to 100 pounds of fuel per sq. ft. of grate per hour has proven to be the most desirable rate.

Limiting the Cut-off

One recent important development (one which makes the new locomotive a practical possibility) is limiting the maximum cut-off. The value of utilizing the expansive properties of steam was familiar to Watt and Stephenson, but, curiously enough, except in certain sporadic instances, this principle was not applied in locomotive design until in 1916, Mr. W. F. Kiesel, Mechanical Engineer of the Pennsylvania Railroad, had the courage to design and build a locomotive in which the maximum cut-off was fixed at 55 per cent of the stroke. This locomotive was operated successfully for a year, both on the testing plant and in road service. The economies which it gave were so marked that the road adopted it as the standard freight locomotive, and today there are 598 of them in service.

The Pennsylvania Railroad has also built and is operating 90 eight-wheel switching locomotives in which the maximum cut-off is limited to 60 per cent of the stroke.

There are, in addition, about 200 Limited Cut-off locomotives operating or in process of construction for other roads.

While it might seem curious that the railroads have waited so long to take advantage of the expansive properties of steam, there is a basic reason for the delay. Many of us can recall the time when fuel could be put on the tender deck for $1.00 per ton. Economy in its use was therefore rather an academic question, very little time or thought was expended on a device whose sole merit was fuel economy.

Today coal costs around $5.00 per ton; consequently, there are but few roads without fuel conservation departments. Every effort is made to conserve its use. The government is insisting that the waste of fuel must cease.

While the Limited Cut-off locomotive had been used abroad to a very limited extent, its use in this country until about eighteen months ago, was confined to a single railroad. Therefore, there is a pardonable lack of current information regarding the principle on which it operates and, naturally, some misinformation is in circulation regarding it.

In the conventional design of locomotive, the maximum cut-off is fixed at from 88 per cent to 91 per cent of the stroke. In the remainder of this discussion such a locomotive will be referred to as a *Full Gear Cut-off*.

A characteristic indicator card from such a locomotive is shown in Fig. No. 1. This is what is known as a "rectangular cycle" and represents a great waste of fuel, as steam follows the piston for nearly the full stroke and is exhausted at a pressure only slightly lower than the working pressure.

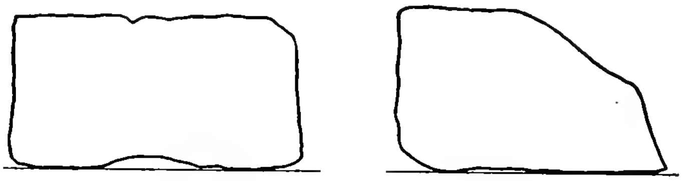


Fig. 1—Full Stroke Indicator Cards of a Full-Stroke and a Limited Cut-Off Locomotive

In a Limited Cut-off locomotive the valve gear and valve characteristics are so arranged that it is impossible to operate the locomotive at any longer cut-off than that for which it is designed. This usually varies from 50 per cent to 65 per cent of the stroke, depending upon the service requirements. Fig. 1 also gives an actual indicator card from a locomotive designed for 60 per cent maximum cut-off. You will observe that after cut-off the steam expands, thereby does a large proportion of its work after it is cut-off from the boiler. It is exhausted at a relatively low pressure, representing a large economy in heat which is thrown away with the "rectangular cycle" shown.

The question is frequently asked why a limited cut-off locomotive (which must necessarily have a higher working pressure or a larger cylinder) can operate at a lower factor of adhesion than can a locomotive with full gear cut-off. Fig. 2 illustrates this point.

All the essential elements of a locomotive are indicated diagrammatically. As in the previous illustration, the cranks are placed in the position where slipping normally occurs. Typical indicator cards for both full gear and limited cut-off are shown below the cylinder for the right or leading crank, and above the cylinder for the left or following crank. Due to the crank positions, the pistons in both the right and left cylinders are equally distant from the ends of the stroke.

The right crank having moved through an angle of 45 deg. from its full forward position, the right piston is exposed to full working pressure, which is 192 pounds for the full gear cut-off and 238 pounds for the limited cut-off.

The left crank has moved through an arc of 135 deg. from its back dead center, and the left piston has passed the cut-off point on the limited cut-off card, but has not

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[*] *A paper read before the Central Railway Club, Buffalo, N. Y.*

yet reached the point of cut-off for the full gear card. The relative pressures are 129 pounds for the limited cut-off engine and 192 pounds for the full gear engine.

The chart at the bottom of the figure No. 2 represents the tractive effort developed at each crank during rotation from its respective dead center, the dotted lines representing the limited cut-off, the full lines the full gear cut-off. With the crank positions shown in the diagram the momentary tractive effort is indicated in table No. 1.

Table No. 1

	Right Crank	Left Crank	Both Cranks
Full Gear Cut-off.....	43,000	41,500	84,500
Limited Cut-off	53,300	27,200	80,500

As the locomotives are of equal power, the mean tractive effort for one complete revolution is 68,100 pounds.

A nominal factor of adhesion of 4 is considered satisfactory for a Mikado locomotive having full gear cut-off. However, at the peak of the torque curve, this factor will be reduced in the present example to

$$\frac{4 \times 68{,}100}{84{,}500} = 3.24$$

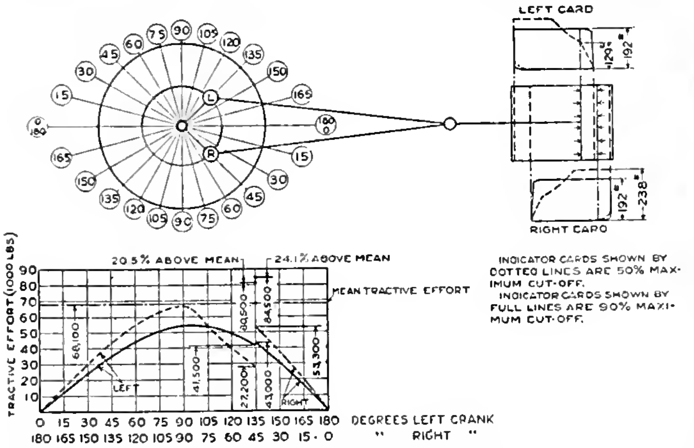


Fig. 2—Diagrams Showing Relative Effect of Full-Stroke and Cut-Offs on the Combined Tractive Limited Forces of Right and Left Driving Wheels

If, under this condition, slipping does not occur, it is reasonable to assume that a locomotive having its cut-off limited to 50 per cent of the stroke will operate as successfully with a normal adhesive factor of

$$\frac{3.24 \times 80{,}500}{68{,}100} = 3.83$$

Very few persons question the advantage of using steam expansively, but there has been a great deal of discussion regarding the capacity of a Limited Cut-off locomotive to start a heavy train under all conditions. It is obvious that without some special starting means it would be practically impossible to start such a locomotive without taking slack very carefully so as to bring the one effective crank into a favorable position.

The starting means which has been employed on all the limited cut-off locomotives so far built in this country was devised by Mr. Kiesel, and consists of small slots in the valve bushings which are lapped by the valve when in its central position. These slots are usually made 1/8 in. wide by 1½ in. long, and communicate with the main steam passages between the valve and cylinder.

A diagrammatic view of this starting arrangement is shown in Fig. No. 3, which indicates two positions of both the right and left cylinders. In the bottom views the right piston is beginning its backward stroke and is exposed to full steam pressure, but as its crank angle is zero it cannot transmit any turning effort. The left piston has reached cut-off position of the main port; impossible to start the locomotive without taking slack.

With the starting ports, steam can enter the left cylinder through the small slot indicated and exert pressure on the piston until it reaches the position shown in the upper figure of the diagram. At this point the small port is cut off by the valve. It will be noted that the right crank has now reached a favorable angle which will permit starting the locomotive without taking slack. The cut-off position of the auxiliary port is from 80 per cent to 85 per cent of the stroke. This starting means is extremely simple, efficient and entirely automatic.

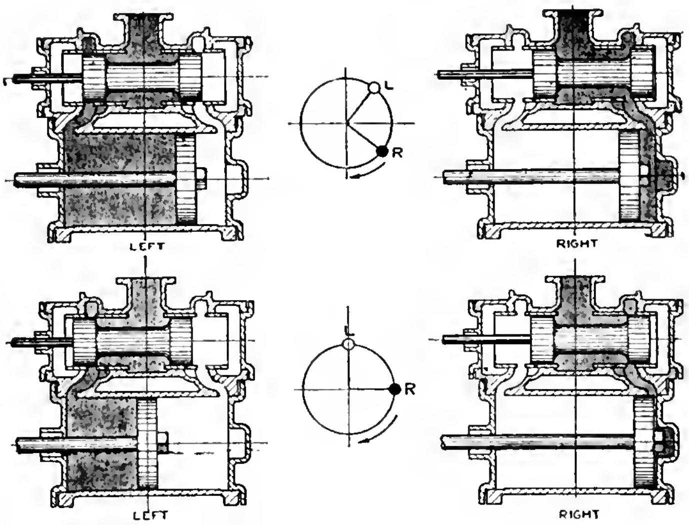


Fig. 3—Diagrams Illustrating the Functions of the Starting Ports

While those who have given the subject sufficient study realize the necessity for providing some starting means in a limited cut-off locomotive, there are others who claim that such means are not necessary to successfully start a locomotive having the cut-off limited to 70 per cent of the stroke. That such reasoning is fallacious will be proven by the following Fig. No. 4. In this illustration the white circles represent the positions of the cranks of a locomotive having full gear cut-off at the instant that the valve has just closed the steam port governing the following crank. This is the position in which the locomotive will have the minimum starting effort. If we take as an example a locomotive having 28 in. by 30 in. cylinders, 63 in. driving wheels and 200 pounds boiler pressure, with 90 per cent maximum cut-off, the nominal tractive effort will be 68,700 pounds. If this engine is required to start with the cranks in the position shown, the starting effort is reduced to 43,400 pounds.

Cylinders	Drivers (Dia)	Pressure Boiler	Cut-Off Main Ports	Starting Ports	Nominal Starting Effort	Minimum Starting Effort
28x30	63 ins.	200 lbs.	90%	None	68,700 lbs.	43,400 lbs.
28x30	63 ins.	211½ lbs.	75%	None	68,700 lbs.	27,750 lbs.
28x30	63 ins.	211½ lbs.	75%	With	68,700 lbs.	43,400 lbs.

FORMULAS

90% Cut-Off 200 Pounds B. P. 75% Cut-Off 211½ Pounds B. P.

$$\text{Min. Starting Effort}=\frac{615.75\text{x}200\text{x}.741\text{x}30}{63}=43{,}400\text{ lbs.}$$

$$\text{Min. Starting Effort}=\frac{615.75\text{x}211\tfrac{1}{2}\text{x}.448\text{x}30}{63}=27{,}750\text{ lbs.}$$

75% Cut-Off 211½ Pounds B. P.
Auxiliary Starting Ports

$$\text{Min. Starting Effort}=\frac{615.75\text{x}211\tfrac{1}{2}\text{x}.701\text{x}30}{63}=43{,}400\text{ lbs.}$$

Assume now a similar locomotive having the same size of cylinders, but with the cut-off limited to 75 per cent of the stroke. With this reduction in cut-off it will be necessary to increase the boiler pressure to 211½ pounds to obtain an equal nominal starting effort of 68,700 pounds. We will further assume that the starting ports are omitted. The gray circles will then indicate the position of the cranks at the moment of cut-off of the main steam port. In this position the leading crank is only 30 deg. from the back dead center, giving a maximum starting effort of 27,750 pounds, or only 64 per cent of that given by the locomotive with full gear cut-off.

By the addition of auxiliary starting ports, the virtual cut-off is lengthened to 88 per cent of the stroke. The position of the cranks will then be as shown by the black circles, and by this means the starting effort is increased to 43,400 pounds, or equal to that of the full gear cut-off.

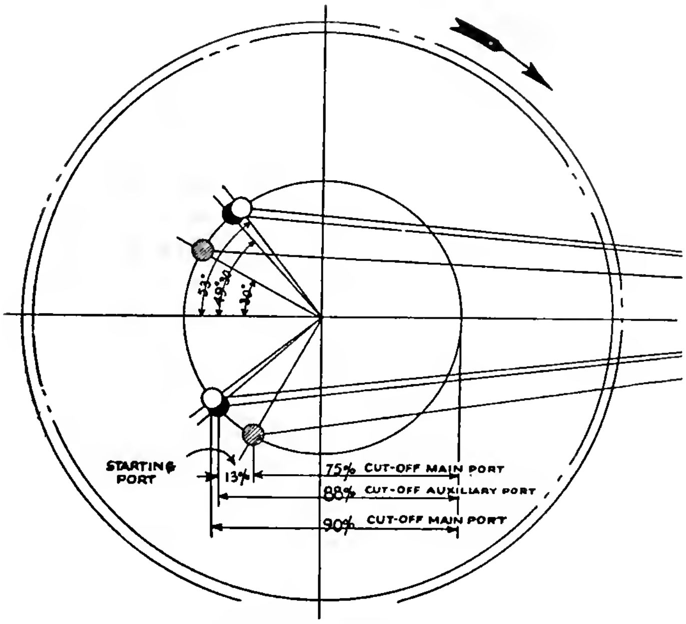


Fig. 4—Effect of Starting Parts on the Minimum Starting Force of a Limited Cut-Off Locomotive

It is obvious from this illustration that for any cut-off less than the maximum with which it is compared, auxiliary starting ports must be provided to give equal starting power.

Thermal Efficiency

The two outstanding reasons for the adoption of the limited cut-off principle in locomotive construction are, *increase in capacity* and *economy in fuel*. Both of these desirable objects may be realized in the same design.

While the major portion of the fuel economy is attributable to the reduction in cut-off a significant measure of it is due to the improved valve conditions which accompany the limitation of the maximum cut-off.

There is a decided tendency today toward longer valve travel as a means of improving valve events and reducing the loss through wiredrawing of the steam into the cylinder at short cut-off.

It is obvious that if the maximum cut-off is reduced in any given locomotive the power will also be reduced until the locomotive reaches the speed at which its sustained power is dependent upon boiler capacity.

Let us assume, for example, a locomotive having 28 in. by 30 in. cylinders, 63 in. driving wheels, 200 pounds boiler pressure and a maximum cut-off of 90 per cent.

The nominal tractive effort of such a locomotive in accordance with the usual formula is 63,400 lbs. If this locomotive was built to deliver the same nominal power with a maximum cut-off of 60 per cent, either the boiler pressure or the cylinder volume must be increased. Assuming that an increase in pressure was most desirable, then a pressure of 228 lbs. is required, or if the same pressure is retained then about 31½ in. cylinder diameter is necessary.

On account of the large diameter of cylinder required it is usually preferable to increase the boiler pressure.

It is important to note here that the application of limited cut-off to a locomotive involves an increase in the weight, as higher pressure requires heavier boiler plate and more substantial staying and bracing. It also necessitates an increase in the strength of the running gear, in direct proportion to the increase in pressure.

Where the required power is obtained by an increase in boiler pressure, the weight increase will approximate 4½ per cent of the locomotive weight. If the pressure remains the same and the cylinders are made larger the weight increase will approximate 3 per cent.

To take full advantage of the increased power at speed, the limited cut-off locomotive should be equipped with a Booster to give the necessary starting power and provide acceleration at low speed.

It is well known that the switching locomotive works habitually in full gear cut-off, also that its operating range of speeds is very low, possibly from two to twelve miles per hour, averaging at the most about four or five miles per hour. Therefore, it is constantly operating under the most favorable conditions for large fuel saving. Thirty per cent of the fuel may be saved in this class of power by limiting the cut-off without incurring the slightest operating disadvantage. The experience of every road which has used limited cut-off switchers is that they are better starters than the conventional locomotive, as well as superior in accelerating their trains.

The saving in fuel is more pronounced where the limited cut-off locomotive operates at such speeds that the maximum cut-off difference exists between it and the ordinary type of locomotive. However, on account of the higher pressure employed, the limited cut-off locomotive always operates on a shorter cut-off than the conventional locomotive, at any speed, therefore, it will show economy in fuel throughout the whole range of speeds, or this economy may be translated into additional power at speed, if desired, as the limited cut-off will produce a horsepower for a smaller expenditure of steam.

In applying the limited cut-off to passenger locomotives, the designer must give consideration to the reciprocating weights which would normally be increased through the use of higher boiler pressure. This handicap may be overcome by care in design of reciprocating parts and use of the better grades of steel.

There are two other factors which tend to compensate for the increased reciprocating weights, one is the increased length of wheel base, the other the higher compression in the limited cut-off locomotive due to the use of an exhaust lap.

Without going into details it may be stated here briefly that the simple Mallet locomotive offers a very attractive field for the use of limited cut-off, as its range of operating speed is such that the maximum economy in fuel can be realized. With full gear cut-off it is difficult to get sufficient boiler capacity for the large cylinder volume. Reducing the maximum cut-off is equivalent to increasing the boiler capacity.

Within the past few years there has been an increasing demand for greater fuel and water capacity on tenders. This has been brought about by long runs and the tendency to higher average operating speed. The limited cut-off by increasing the operating radius of a locomotive, through economy in the use of fuel and water, offers a better solution than an increase in tender capacity.

While the initial cost of the Limited Cut-off Locomotive will exceed that of the plain engine on a nominal tractive effort basis, it will not be operated on that basis. Therefore, it would seem more logical to base the comparative purchase price on the power which the locomotive will deliver at the operating speed, and in addition take into consideration the fact that the limited cut-off locomotive will save from 5 per cent to 10 per cent of its cost annually in fuel and water. On this basis of calculation, which is a conservative one, the limited cut-off locomotive will prove to be the better bargain in contributing to efficient railroad operation.

Centenary of the Baltimore & Ohio

Transportation Exhibition and Pageant at Baltimore Opens Next Month

A complete outdoor and indoor exhibition of transportation will be the crowning climax of the celebration of the one-hundredth anniversary of the Baltimore & Ohio Railroad. The "Fair of the Iron Horse," the name given to the Baltimore & Ohio Centenary exhibition and pageant is to be held at Baltimore, Md., for two weeks, September 24th to October 8th, 1927.

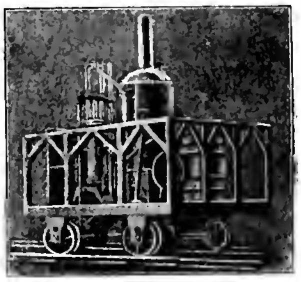
On a thousand-acre tract at Halethorpe, a suburb of Baltimore, a large loop track has been laid down around a 25 acre plaza, where a massive grandstand is being erected; an old-time tavern has been put up; a Hall of Transportation, 502 feet long, constructed; and other auxiliary buildings provided. There will be ample room to accommodate more than 50,000 visitors daily.

The outstanding feature will be the historical pageant, a moving drama of transport which will portray the unfolding of the full scheme of inland transportation in the United States from earliest times up to the present. Included in the spectacle will be, first, the Indian mode of travel, the primitive prairie schooners, stage coaches, post chaises and so on through the horse-drawn age. This will be followed by the locomotive "Tom Thumb," the first locomotive built in America in 1829, followed by engines of the grasshopper type of 1830, the camel backs of 1840, engines of the Civil war period and on up to the latest in locomotive design of the present day. The latter is well represented on the Baltimore & Ohio by the recently constructed "Presidents" class high speed passenger engine of the road.

It is interesting to compare the present day power with Peter Cooper's "Tom Thumb" of 1829. Peter Cooper, afterwards celebrated as a great philanthropist, was at the time a merchant and alderman of New York, but deeply interested in the prosperity of Baltimore where he had heavy investments. At the time nearly all Americans were amateur mechanics so it excited no surprise that a merchant should design a locomotive.

"President" Class Pacific Type Locomotive of the Baltimore & Ohio

Cooper's engine was a tiny locomotive with one upright cylinder 3¼ x 3½ inches, and an upright boiler having tubes made from gun barrels. Draft for the fire was maintained by a revolving fan. It performed the duties for which it was built, which were really of a missionary character. It did prove that steam power could be used to operate the Baltimore & Ohio Railroad and served to revive the spirits of the promoters of the enterprise who were becoming despondent about the prospects of the property. The "Tom Thumb" was little bigger than a modern hand car and was only about 1½ horsepower, but its design seems to have exerted considerable influence on our early locomotives. It was only shortly after the experiments with Peter Cooper's model locomotive that the management of the railroad, advertised offering a premium of $4,000 for a locomotive built in the United States which would draw 15 tons gross weight at fifteen miles per hour. In due time this offer brought to the company five locomotives, all built at different places, all different in design, but none of them imitating British models.



Locomotive "Tom Thumb"

The Great Western Railway of England is sending two locomotives for the exhibit. These are the "North Star," one of the pioneer engines of the road, and the latest and most powerful high speed passenger locomotive in Great Britain, the "King George V." The latter engine was described briefly in the July, 1927 issue of Railway and Locomotive Engineering.

Floats depicting the inception and starting of the Baltimore & Ohio as well as other events associated with railroad development will be a part of the pageant.

The Hall of Transportation will be a museum of exhibits illustrative of the growth of the modern railroad: rails, ties, bridges, signals and safety, telegraph and telephone devices, the first sleeping car and the latest and many other interesting education exhibits. Such is a brief outline of the miniature "world's fair of transportation" which will afford the public an opportunity of seeing the effort and great industry that has contributed so largely to the growth and general welfare of the country.

Efficiency Due to Improved Equipment

The remarkable increases in the operating efficiency of the railroads during the recent years, particularly in the period since the war, are creditable in large part to advances in the design and maintenance of locomotives and freight cars, according to William J. Cunningham, professor of transportation at Harvard University.

"Except in the important factor of return on property investment," Professor Cunningham points out, "the railroad record of 1926 is one of superlatives. It had the largest volume of ton-miles, the greatest operating revenues, the largest net income, the highest operating efficiency, and the standard of public service was never before equaled in quality.

An Encouraging Record

"The record as a whole is encouraging to those charged with the determination of executive policies, who during the past six years have courageously invested about $800,000,000 per year in capital improvements on the railroads of the United States, even though the return on the total investment in a year with such favorable results otherwise is disappointingly low. That courage is born of a faith that the Transportation Act of 1920 means what it says, namely, that the railroads as a whole or collectively, in teritorial groups, shall be permitted to earn a fair return on the value of property devoted to public service, if operated with honesty, efficiency and economy. The return last year was better than in any year since the Act was passed, but it was too far short of a fair return. . . .

"The proportionately greater cost of maintaining locomotives and cars than of maintaining way and structures and of conducting transportation is not an indictment of the efficiency of the mechanical departments of the railroads. Instead, in the main, it is the reflex of important advances in the art of transportation.

More Ton-Miles Produced

"The notable achievements in the constant increases in the load per train and otherwise in producing more units of transportation with less units of work have been made possible in large part by the steady development in the power, capacity and efficiency of equipment. Heavier and more powerful locomotives with economizing devices and the use of larger capacity cars produced more ton-miles per train-mile, per train crew hour and per ton of fuel, but they add to equipment maintenance costs. The striking increase in freight transportation efficiency has been purchased in substantial part by heavier costs in maintenance of locomotives and cars, but the net result has been a lower cost for hauling a ton of freight one mile and the ability to increase the capacity of lines and terminals."

New Pullman Single Room Overnight Car

A new type of sleeping car, for overnight runs and containing only single bedrooms, has been designed and built by the Pullman Company.

When a passenger boards this car, and goes into a room, it is like walking into a hotel bedroom. There he will find a regular bed, instead of a berth, already made and awaiting occupancy. The beds are similar to those placed in private cars and have deep springs and spring mattresses. They are of a luxurious type and represent a combination of ideas of the best manutacturers. Each bed is 32 inches wide by 6 feet, 5⅝ inches long. Silk coverlets add a touch of distinction.

Each room contains full toilet facilities, compactly arranged, the washstand and hopper having the appearance of an upholstered chair. When the back is folded down the washstand can be used, with hot and cold water as usual, and there is also a dental faucet. A thermos bottle and glass are in a holder at one side. There is a mirror and glass shelf above the washstand, and a long mirror in the inside of each entrance door.

A small folding table, attached to the wall opposite the bed, can be used for writing, to hold toilet articles, or for breakfast service. The floor is covered with marbleized rubber tiling in black and cream squares, with a rug at the bedside. At the head of the bed is a shoebox with a door in the corridor wall so the porter can remove and replace shoes without disturbing the passenger. There is a rack for towels and an especially designed waste basket. Ample baggage space is provided under the bed and in racks.

The heating and ventilating systems are so complete that extremes of personal preference can be obtained by passengers. Two pipes running the length of the car under the windows in the corridor provide the general heat, sufficient to eliminate the chill from the car; while a radiator under the foot of each bed can be turned on if the traveler desires added warmth. In addition to the usual Pullman ventilation devices in the roof of the car, and the window sash by means of the vent-door device slide, a current of air can be obtained in the lower part of the entrance door. Each room also has a 9-inch electric fan. Double window shades are provided; the usual silk shade rolling from the top, and a light waterproof curtain that rolls from the bottom to cover an open screened window and prevents cinders falling on the bed.

Each car contains 14 bedrooms with communicating doors for the convenience of those traveling together. In addition to locks all doors have sliding bolts. The rooms are decorated in soft colors being alternately in greenish-grey wall tone with olive green paneling and delicate decorative striping and the frieze in vari-colored decoration, and buff and brown wall color with similar decoration.

These cars are designed purely for short night runs, where passengers entrain between 10 and midnight and arrive at their destination early the next morning. Consequently they are not adapted to daylight travel and there are no chairs or seats in the rooms. If used in the daytime 50 per cent of the passengers would be forced to sit on the beds, comfortable though they be, with their backs to the locomotive, as is the practice in European sleeping cars. So there is a marked difference not only between them and the Pullman standard open section sleeper, but the Pullman drawing room cars, also.

Cost of Fuel Declines Slightly

The Interstate Commerce Commission has just made public its analysis of fuel expenditure in railroad train service for the month of May, 1927. These figures exclude fuel for switching locomotives, and therefore include only the fuel consumed in line-haul freight and passenger train service on Class I railroads.

The coal consumption in May, 1927, was 7,723,581 tons as compared with 7,851,497 tons in May, 1926.

Fuel oil consumed in May, 1927, was 165,804,347 gallons as compared with 165,606,774 gallons in May, 1926.

The total cost of coal and fuel oil in May, 1927, was $25,093,990 as compared with $25,380,365 in May, 1926.

For the first five months of 1927 coal consumed aggregated 41,345,041 tons, and fuel oil 840,832,430 gallons, as compared with 42,444,857 tons of coal and 831,501,684 gallons of fuel oil consumed in the first five months of 1926.

The total cost of the fuel consumed by the Class I railroads for the first five months of the present year was $135,306,316, as compared with $135,668,384 for the first five months of 1926, a decrease of $362,068.

Equipment Installed in First Half Year

Class I railroads in the first six months this year installed 38,041 freight cars in service, according to reports just filed by the rail carriers with the Car Service Division of the American Railway Association.

This was a decrease of 15,541 cars compared with the number placed in service during the corresponding period last year.

Of the total number placed in service in the first six months this year, the railroads installed 7,790 freight cars in the month of June, which included 4,333 box cars, 1,953 coal cars and 1,165 refrigerator cars.

The railroads on July 1 this year had 23,279 freight cars on order compared with 37,253 on the same date in 1926.

1,040 Locomotives Placed in Service

Locomotives placed in service in the first six months of 1927 totaled 1,040 of which 258 were installed in June. In the first six months last year, the railroads placed in service 1,117 locomotives. Locomotives on order on July 1 this year numbered 237 compared with 646 on July 1 last year.

These figures as to freight cars and locomotives include new and leased equipment.

Notes on Domestic Railroads

Locomotives

The Missouri Pacific Railroad is inquiring for 5 Mikado type locomotives and 5 Santa Fe type locomotives.

The Chesapeake & Ohio Railway has withdrawn its inquiry for 30 switching locomotives.

The Louisville, Henderson & St. Louis Railway has ordered one Pacific type locomotive from the American Locomotive Company.

The South Manchurian Railway is inquiring for 5 two-cylinders Mikado type locomotives through the locomotive builders, and asking for bid on 5 three-cylinders locomotives.

The Alberta Great Waterways have inquired for bids on 2 Consolidation type locomotives.

The Chinese Government Railways are inquiring for 4 Pacific type and 8 Mikado type locomotives through the builders.

The New York Central Railroad has ordered 11 locomotives tenders from the American Locomotive Company.

The Erie Railroad plans buying two Diesel-electric locomotives.

Passenger Cars

The Chesapeake & Ohio Railway has ordered 3, 70-ft., all-steel mail and express cars from the Pullman Car & Manufacturing Corporation.

The Delaware & Hudson Company is inquiring for 8 baggage and mail cars.

The Central Railroad of New Jersey has ordered 25 coaches from the Bethlehem Steel Company.

The Great Northern Railway is inquiring for one gas-electric motor car.

The New York, New Haven & Hartford Railroad has ordered 15 steel underframes from the Standard Steel Car Company.

The Reading Company is inquiring for 10 baggage and mail cars.

The Erie Railroad has ordered 25 all-steel baggage and express cars from the Standard Steel Car Company.

The New York Central Railroad has ordered 4 business cars from the Pullman Car & Manufacturing Corporation.

The Lehigh Valley Railroad is inquiring for 2 steel club-dining cars and 2 steel dining cars.

The Southern Pacific System has ordered two business cars from the Pullman Car & Manufacturing Corporation.

The Santa Fe System has ordered 8 buffet library cars, 10 dining cars and 15 baggage and mail cars from the Pullman Car & Manufacturing Corporation.

The Lehigh Valley Railroad is inquiring for 3 gas-electric rail motor cars and 4 trailer cars.

The Erie Railroad is now inquiring for 25 all-steel suburban passenger coaches.

The Chicago & Alton Railroad has ordered 4, 72 ft. mail, baggage and passenger gas-electric rail motor cars from the Electro-Motive Company, Cleveland, Ohio.

The Gulf, Mobile & Northern Railroad has ordered one business car from the American Car & Foundry Company.

Freight Cars

The Fruit Growers Express has ordered 325 refrigerator car underframes from the Ryan Car Company.

The Western Maryland Railway has ordered 2 extension side dump cars from Clark Car Company, Pittsburgh, Pa.

The Michigan Central Railroad has ordered one plow car from the Rodger Ballast Car Company.

The Corn Products Company, Perkin, Ill., has ordered an extension side dump car from the Clark Car Company, Pittsburgh, Pa.

The Johnson Mining Company has ordered 2 air dump cars from the Clark Car Company, Pittsburgh, Pa.

The United States Cast Iron Pipe & Foundry Company has ordered one extension side dump car from the Clark Car Company, Pittsburgh, Pa.

The New York Central Railroad has ordered 5 special flat cars 81½-ton capacity and 9, 92-ton capacity from the Standard Steel Car Company.

The Lehigh Valley Railroad has been inquiring for prices on 500 steel coal cars and 500 box cars.

The Standard Oil Company of New Jersey plans buying 8 hopper bottom coal cars of 55-ton capacity.

The Wichita Falls & Southern Railroad has ordered 50 steel-frame box cars of 40 tons capacity from the American Car & Foundry Company.

The Great Northern Railway has ordered 250 gondola cars of 70-ton capacity from the Pressed Steel Car Company.

The Norfolk & Western Railway has been inquiry for prices on 2 wrecking cars of 200-ton capacity.

The Canadian Pacific Railway will build at its Angus shops 2 special flat cars of 120-ton capacity.

The Clinton & Oklahoma Western Railroad has ordered 10 steel-frame box cars of 40-ton capacity from the American Car & Foundry Company.

The Carnegie Steel Company has placed an order for the repairs of 150 steel hopper cars with the Pressed Steel Car Company.

The Lehigh Valley Railroad is inquiring for price on the repair of 500 wooden box cars and 500 steel coal cars.

The Chicago & North Western Railway has ordered 50 caboose car underframes from the Bettendorf Company, Bettendorf, Iowa.

The Anglo-Mexican Petroleum Company has been inquiring for 15 box cars and 15 gondola cars.

The Chicago, Rock Island & Pacific Railway has ordered 100 composite gondola car bodies of 50-ton capacity, from the American Car & Foundry Company.

The Michigan Central Railroad has ordered 2 double-plow cars from the Rodger Ballast Car Company.

Buildings and Structures

The Atchison, Topeka & Santa Fe Railway plans the construction of a coaling station of 1,000-ton capacity at Emporia, Kans., also for the enlargement of the yards at San Angelo, Tex.

The Illinois Central Railroad plans the re-building of the water treating plant at Denison, Iowa.

The Morrissey, Fernie & Michel Railway plans the reconstruction of its shops which were destroyed by fire at Fernie, B. C.

The Pennsylvania Railroad has awarded a contract for the construction of a freight house at Cleveland, Ohio, which will cost approximately $150,000.

The Chicago, Milwaukee & St. Paul Railway plans the construction of minor shop buildings at Tomah, Wis.

The Missouri Pacific Railroad plans for the construction of a water station and water treating plant at Hermann, Mo.

The New York Central Railroad has awarded a contract for the construction of a baggage sub-station, passenger station and garage at Buffalo, New York, to cost approximately $3,000,000.

The Baltimore & Ohio Railroad has awarded a contract for the construction of water treating plants at Willard and Attica Junction, Ohio, to cost approximately $40,000.

The Delaware, Lackawanna & Western Railroad plans the construction of a three-story railroad Y. M. C. A. building at Elmira, New York, to cost approximately $75,000.

The Chicago, Burlington & Quincy Railroad has awarded a contract for the construction and installation of a two-track standard N. & W. type electric cinder handling plant at Brookfield, Mo., also a one-track N. & W. type electric cinder handling plant at Quincy, Ill.

The International Great Northern Railroad has awarded a contract for the construction of an automatic electric coaling station at Trinity, Texas.

The St. Louis-San Francisco Railway has awarded a contract for the construction of a 400-ton reinforced concrete simplex automatic coaling station at Yale, Tenn.

The Central Railroad of New Jersey had awarded a contract to the Roberts & Schaefer Company for the construction of a 600-ton, four-track, reinforced concrete automatic electric coaling station, with sanding facilities at Bethlehem, Pa. This plant has been designed to mix various proportions of anthracite and bituminous coals mechanically.

The Cleveland, Cincinati, Chicago & St. Louis Railway are receiving bids for the construction of a roundhouse and terminal building at South Anderson, Ind., at a total cost of approximately $200,000.

The Virginian Railway has awarded a contract for the construction of a sub-track between Roanoke, Va., and Princeton, W. Va., to cost $35,000.

The St. Louis-San Francisco Railway has awarded a contract to the Roberts & Schaefer Company, Chicago, for the construction of a 400-ton, four-track, reinforced concrete simplex automatic electric coaling station at Kansas City, Mo.

The Canadian National Railways plans to build an addition to its roundhouse at Kamloops, B. C., also coaling stations at that point and at Prince Rupert, B. C., and locomotive shops at Point St. Charles, Que.

The Frisco System has contracted with the Ogle Construction Company for one, 200-ton, double-track coaling station at Cherokee, Kansas.

The Southern Pacific System has awarded a contract for the construction of two-story, reinforced concrete, brick and steel fruit warehouse on Front street, at Julia street, New Orleans. The cost of the structure, which will include an office building attached to the warehouse, will cost about $100,000.

The Delaware, Lackawanna & Western Railroad have made plans for a new passenger station at Paterson, N. J., to cost around $100,000.

The Chesapeake & Ohio Railway has awarded a contract for the sub-structure of a new railroad bridge across the Ohio river between Cincinnati and Covington, Ohio. This work is to cost $500,000 and includes, besides other work, the installation of several large piers in the Ohio river.

The St. Louis-San Francisco Railway has awarded a contract to the Ogle Construction Company, Chicago, for the construction of a 200-ton, two-track, electric, reinforced concrete coaling station at Cherokee, Kan.

The Chicago & North Western Railway has awarded a contract for the construction of a boiler house at the Chicago avenue terminal, Chicago, to cost approximately $30,000.

The Canadian National Railway has been getting bids on one 100-ton coaling station to be built at Hope, B. C., and has let contracts for a similar station at Camrose, Alta., and one at Moose Jaw, Sask.

The Panhandle & Santa Fe Railway has awarded a contract for the construction of a one-story warehouse and storage room, with outside dimensions of 270 ft by 50 ft., at Amarillo, Texas.

The Rock Island Lines has awarded a contract for the construction of a boiler washout plant at Hubert, Ark. This road is also having a water treating plant installed at Kansas City, Kans.; also for mechanical coaling station at Mineola, Kans., and at Iowa Falls, Iowa.

The Norfolk & Western Railway plans to erect a 1,000-ton steel crane runway at Portsmouth, Ohio.

Supply Trade Notes

R. V. Jones, representative of the **Trumbull Steel Company**, has been placed in charge of the branch office at Rochester, New York.

William M. Horsell, sales representative of the **J. G. Brill Company**, Philadelphia, Pa., in charge sales covering the central states has been transferred to its Philadelphia plant to represent the company's electric railway division in the southeastern territory.

Walter C. Carroll, vice-president of the **Inland Steel Company**, Chicago, Ill., has resigned to become president of the **National Association of Sheet and Tin Plate Manufacturers**, with headquarters at Pittsburgh, Pa.

The Lincoln Electric Company, Cleveland, Ohio, has moved its district office from 1808 Railway Exchange building, St. Louis, Mo., to the Davidson building, Kansas City, Mo., in charge of **Robert Notvest**. **A. H. Homrighaus**, formerly of the St. Louis office, has been place in charge of a branch office established at Nicholas building, Toledo, Ohio.

W. F. Hart, president of the **Verona Tool Works**, with headquarters at Pittsburgh, Pa., has resigned to become connected with the **Bethlehem Steel Company**, Bethlehem, Pa., and has been succeeded by **W. F. Schleiter**, formerly vice-president of the **Dilworth, Porter & Company**. **W. W. Glosser**, general sales manager of the **Verona Tool Works**, has been appointed vice-president and general manager, with headquarters at Pittsburgh, Pa.

W. F. Hosford has been appointed comptroller of manufacture of the **Western Electric Company**, with headquarters at New York City, succeeding **James W. Bancker**, elected a director of the company and vice-president in charge of purchases and traffic.

The More-Jones Brass & Metal Company has been reorganized and is now a division of the **National Bearing Metals Corporation**, recently incorporated, with general offices at St. Louis, Mo.

The Eichman Machinery Company, Kansas City, Mo., now represents the **Whiting Corporation**, Harvey, Ill., in Kansas and Missouri. The **Huey & Philp Hardware Company**, Dallas, Texas, represents the corporation in Oklahoma and Texas; **L. H. Staley**, New Orleans, La., represents the corporation in Louisiana, the southern part of Mississippi, and the **H. B. Wilson Company**, St. Louis, Mo., represents the corporation in Arkansas. The Whiting Corporation will build a one-story addition to its plant to cost $35,000.

The Electric Storage Battery Company, Philadelphia, Pa., has moved its Detroit branch to 8051 West Chicago boulevard; **H. G. Carron** is manager of the branch. The company's San Francisco branch is in charge of **G. R. Murphy**, manager. The company recently opened a new factory branch at Hunting Park avenue, Philadelphia, Pa., **W. C. Hooven** is manager.

Thomas Mahar has been appointed manager of the service department of the **American Arch Company**, with headquarters at New York.

James W. Bancker, controller of manufacture of the **Western Electric Company**, has been elected a director and vice-president in charge of purchasing and traffic, succeeding **Jay B. Odell**, deceased.

William S. Kriebel, Jr., has been appointed a salesman in the Philadelphia territory for the **Bridgeport Brass Company**, Bridgeport, Pa., with headquarters at Bankers Trust building, Philadelphia, Pa.

Charles R. Ellicott, eastern manager of the **Westinghouse Air Brake Company**, has been elected resident vice-president of that company, with headquarters at New York. Mr. Ellicott was born in Chicago, where his early education was received in 1902; he was graduated as a Bachelor of Science from the Sheffield Scientific School of Yale University. He entered the employ of the Westinghouse Air Brake Company in August of that same year, as a special apprentice in the Wilmerding shops, and was later made mechanical expert at New York. From 1905 until 1912 he served as representative of the company, first in New York and then in Boston. He was appointed assistant eastern manager in 1912 and promoted to the position of eastern manager in 1920.

Aubrey J. Grindle, vice-president of the **Grindle Fuel Equipment Company**, Harvey, Ill., a subsidiary of the **Whiting Corporation**, has resigned to organize the **Pulverized Fuel Equipment Company**.

J. Dalrymple Rogers, formerly manager of the London, England, office of the **Baldwin Locomotive Works**, has been appointed London representative of the **International Railway Supply Company**.

The National Machinery Company, Tiffin, O., and the **Chambersburg Engineering Company**, Chambersburg, Pa., announce a unified sales agency, with offices in Chicago, Detroit and New York City. **K. L. Ernst** is district manager of 565 Washington street, Chicago. The organization is known as the **Chambersburg National**, complete forging equipment.

Charles F. Simpson has been appointed district engineer for Tennessee district, for the **Portland Cement Association**, with headquarters at the Cotton State building, Nashville, Tenn.

The Power Specialty Company, New York, and the **Wheeler Condenser & Engineering Company**, Carteret, New Jersey, have been consolidated as have the subsidiaries of both companies and will be known in the future as the **Foster Wheeler Corporation**. The officers of the new company are: **J. J. Brown**, chairman of the board; **Pell W. Foster**, vice-president and treasurer; **L. B. Nutting**, president; **John Primose, H. S. Brown** and **W. E. Dowd, Jr.**, vice-presidents; **D. McCulloch**, secretary and general manager, and **W. F. Keenan, Jr.**, chief engineer.

M. J. Harkless has been appointed sales engineer of the **Independent Pneumatic Tool Company**, Chicago, Ill., Mr. Harkless was previously an engineer of the railway department of the **Buda Company**. Harvey, Ill.

The Ingersoll-Rand Company, New York City, has opened a branch office at 236 High street, Newark, New Jersey. **F. K. Armstrong**, formerly connected with the company's sales branch, has been appointed manager of the Newark office.

Carl H. Beck, for seven years assistant eastern manager of the **Westinghouse Air Brake Company**, New York, has been appointed general sales manager of the company with headquarters at Wilmerding. Mr. Beck was graduated from the Pennsylvania State College in 1905 as a Bachelor of Science, and in 1911 received his M. E. degree from the same college. He entered the employ of the Westinghouse Air Brake Company as a special apprentice in 1905, and after filling special shop and field assignments was transferred to the St. Louis office in 1907 and given the position of steam road inspector. In 1909 he was advanced to the position of representative of the Westinghouse Traction Brake Company in the same city, which position he held until 1919, when he was made special representative of the Safety Car Devices Company at Wilmerding. Mr. Beck's next promotion came in 1920, when he was made assistant eastern manager of the Westinghouse Air Brake Company, which position he was holding until his new appointment.

The Air Reduction Company, Inc., New York, has purchased the business, insofar as the manufacture and sale of oxygen, acetylene, and kindred products are concerned, of the **United Gas Improvement Contracting Company**, a subsidiary of the **United Gas Improvement Company**, and the **United Oxygen Company**, Philadelphia.

T. J. Powell has been appointed representative of the **Rome Iron Mills, Inc.**, in the St. Louis district. Mr. Powell's headquarters will be in Railway Exchange building, St. Louis, Mo.

The American Rolling Mill Company, Middletown, Ohio, has moved its St. Louis, Mo., office from the Boatman Bank building to Ambassador building.

The Andrews-Bradshaw Company, Pittsburgh, Pa., who have for some time past owned a controlling interest in the **Tracy Engineering Company**, San Francisco, have recently acquired full ownership of that company's entire plant. While many of the original basic patents were held jointly by the two companies, the purchase of the Tracy Engineering Company gives the Andrews-Bradshaw Company absolute title to all the valuable Tracyfier patents.

The location of the factory in Pittsburgh also gives the Andrews-Bradshaw Company a much better opportunity to continue their extensive development and research work on a far greater scale than formerly.

The Tracyfier organization has been augmented by the transfer of **George Ahlworth**, former plant superintendent of the Tracy Engineering Company, and **Carl Petersen**, chief draftsman, who is also moving east to join the Andrews-Bradshaw Company forces.

Sprout, Waldron & Company, Muncy, Pa., have taken over all the patterns, equipment, etc., of the **Valley Iron Works**, Williamsport, Pa. and will now handle all Monarch Transmission Appliances including a complete line of milling machinery equipped with Westinghouse motors and controllers.

To take care of this transmission business a separate and distinct department has been organized. A new machine shop and stock room with 5000 square feet of floor space has been built and equipped. The foundry has been enlarged to double the former capacity and special machinery for manufacturing this class of equipment has been installed. Large stocks of all sizes, standard bearings, couplings, collars, take-ups, etc., will be maintained for immediate shipment.

Items of Personal Interest

F. E. Boehm has been appointed road foreman of engines of the Fort Wayne division of the Western region of the Pennsylvania Railroad, with headquarters at Fort Wayne, Ind., succeeding **E. A. Burchiel**, promoted.

W. L. Curtis, mechanical engineer of the New York Central Railroad, with headquarters at New York, N. Y., has been transferred to water service department.

O. B. Keister has been appointed general superintendent of the Southern Railway, with headquarters at Knoxville, Tenn.; **L. F. DeRamus** has been appointed general superintendent, with headquarters at Danville, Va.

C. A. Fisher, fuel supervisor on the Great Northern Railway, has been appointed master mechanic, with headquarters at Grand Forks, N. D.

H. H. Vanderbosch has been appointed roundhouse foreman of the Baltimore & Ohio Railroad, with headquarters at Garrett, Ind., and **W. H. Weatherspoon** becomes night roundhouse foreman, with the same headquarters. **J. B. Harwood** has been appointed general foreman, with headquarters at Newcastle Junction, Pa.

W. E. Harmison, master mechanic on the Western division of the Erie Railroad, has been transferred in the same capacity to Port Jervis, New York.

W. C. Hudson has been appointed general superintendent of the Southern Railway, with headquarters at Chattanooga, Tenn.; **H. H. Vance** has been appointed general superintendent of the Southern Railway, with headquarters at Birmingham, Ala., and **B. G. Fallis** has been appointed general superintendent, with headquarters at St. Louis, Mo.

W. B. Shea has been appointed superintendent of shops of the Missouri Pacific Railroad, with headquarters at De Soto, Mo.

F. S. Weisbrook has been appointed general manager of the Davenport, Rock Island & Northwestern Railway, with headquarters at Davenport, Iowa, succeeding **C. B. Rodgers**.

C. G. Slagle has been appointed master mechanic of the Baltimore & Ohio Railroad, with headquarters at Indianapolis, Ind.; **C. F. Smith** has been appointed assistant to the general manager of the Baltimore & Ohio Railroad, with headquarters at Cincinnati, Ohio.

Charles Furness has been appointed acting master mechanic of the Portland division of the Boston & Maine Railroad.

J. M. Whalen, master mechanic of the Missouri Pacific Railroad, with headquarters at St. Louis, Mo., has his jurisdiction extended to cover the St. Louis Terminal; **J. L. Butler** has been appointed master mechanic, with headquarters at Poplar Bluff, Mo., succeeding **W. A. Curley**.

N. L. Wiggins has been appointed fuel superintendent of the Boston & Maine Railroad, with headquarters at Boston, Mass., succeeding **J. R. Annis**, transferred to Portland, Me.; and **W. H. McClenathan** is appointed fuel supervisor, with headquarters at Woodsville, N. H.

Bernard Cook has been appointed general foreman of the locomotive shops of the Norfolk & Western Railway, with headquarters at Roanoke, Va., succeeding **H. F. Staley**; **O. C. Farris** has been appointed car foreman, with headquarters at Clare, O., succeeding **J. M. Sammons**.

L. K. Sillcox, general superintendent of motive power of the Chicago, Milwaukee & St. Paul Railway, has been granted a leave of absence for two months on account of ill health; **K. F. Nystrom** has been appointed master car builder, with headquarters at Chicago, succeeding **C. G. Juneau**, deceased.

J. W. Morse has been appointed assistant road foreman of engines of the Monongahela division of the Pennsylvania Railroad, with headquarters at Youngwood, Pa., succeeding **S. W. Dobson**, deceased. **J. F. Manning, Jr.**, has been appointed assistant road foreman of engines Conemaugh division, with headquarters at Sharpsburg, Pa., succeeding **J. W. Morse**. Mr. Manning was formerly located at West Brownsville Junction, Monongahela division, and his position was abolished.

Charles F. Rorabaugh, traveling engineman of the Pennsylvania Railroad, has been appointed assistant road foreman of engines, with headquarters at Pittsburgh, Pa., succeeding

J. Beswick, deceased. **Harry E. Hays**, traveling engineman, has been appointed assistant road foreman of engines, with headquarters at Pittsburgh, Pa., succeeding **W. W. Bond**, retired.

J. S. Hagan has been appointed electrical engineer of the Central Railroad of New Jersey, with headquarters at Elizabethport shops, Elizabeth, New Jersey.

J. W. Smith, general manager of the Indiana Harbor Belt Railroad, has resigned, to become assistant to the president of the Boston & Maine Railroad, with headquarters at Boston, Mass.

R. A. Whitsitt, assistant master mechanic of the Tennessee Central Railway, has been appointed master mechanic, with headquarters at Nashville, Tenn., succeeding **E. L. Mauk**, deceased.

J. O. Bell, superintendent of the Chicago division of the Chicago & Eastern Illinois Railway, with headquarters at Danville, Ill., has been appointed superintendent of transportation, with headquarters at Chicago, Ill., succeeding **C. B. Anderson.**

A. W. Standiford, master mechanic of Illinois and St. Louis division of the Chicago & Eastern Illinois Railway, with headquarters at Salem, Ill., has been transferred to the Chicago division, with headquarters at Danville.

R. T. Taylor, assistant superintendent of the Northern Pacific Railway, with headquarters at Billings, Mont., has been appointed superintendent of the Yellowstone division, with headquarters at Glendive, Mont., succeeding **O. F. Ohlson.**

T. A. Saunders, general foreman car department of the Tennessee Central Railway, has been appointed master car builder, with headquarters at Nashville, Tenn.

O. F. Ohlson has been appointed superintendent of the Lake Superior division of the Northern Pacific Railway, with headquarters at Duluth, Minn.

E. J. Wegmiller, master mechanic of the Evansville division of the Chicago & Eastern Illinois Railway, with headquarters at Evansville, Ind., has been transferred to the Illinois and St. Louis division, with headquarters at Salem, Ill., succeeding **A. W. Standiford.**

Obituary

Clarence W. Huntington, formerly president of the Virginian Railway, died on July 12, at Elizabeth, New Jersey. Mr. Huntington was born in May, 1857, at Newark, New Jersey, and was educated at Newark Academy and Dorchester High School, Boston, Mass. He entered railway service in 1876 as a brakeman on the Chicago, Rock Island & Pacific Railway and continued with that company until 1892. He then became assistant superintendent of the Des Moines, Northern & Western Railway. He later served as superintendent of the same road and left in 1894 to become general superintendent of the Iowa Central Railroad, which position he left in 1902 to become general superintendent of the Central Railroad of New Jersey. In 1914 he was elected vice-president and general manager of Minneapolis & St. Louis Railroad, with headquarters at Minneapolis, Minn., and in 1916 he became chairman of the board of directors of the Virginian Railway, and in 1917 was elected president of the company and served in that capacity until April, 1925, when he resigned.

Jay B. Odell, a vice-president and director of the Western Electric Company, died July 8 at New Rochelle, New York, following an operation for appendicitis. Mr. Odell was born in 1883 at Iowa Falls, Iowa. He was educated in the public schools and at Cornell University, from which he graduated in 1904. He entered the employ of the Western Electric Company in New York in 1904, later going to the Chicago works of the company at Hawthorne. He was then transferred back to New York where he served as an executive in the distribution department until 1918, when he was appointed manager of the distributing plant in Richmond, Va. He later returned to New York to take charge of the company's distributing plant. In 1924 he became assistant to the president, and in January, 1926, was elected a vice-president in charge of purchasing and traffic, which position he held at the time of his death.

Benjamin Franklin Bush, former president of the Western Maryland Railroad, the Western Pacific Railroad, the Denver & Rio Grande Western Railroad and the Missouri Pacific Railroad, who retired in 1924 as chairman of the board of directors of the Missouri Pacific, died on July 29, at St. Louis, Mo. Mr. Bush was born at Wellsboro Pa., July 5, 1860 He entered railway service in 1882 as rodman on Northern Pacific Railway. In 1887 he was appointed division engineer on the Union Pacific Railroad. A few years later he became chief engineer and general superintendent of the Oregon Improvement Company, with headquarters at Seattle, Wash. Mr. Bush served as general manager for the Northwestern Improvement Company, with headquarters at Roslyn, Wash., controlling coal properties of the Northern Pacific Railway from 1896 to 1903. He was elected president of the Western Maryland in 1907, serving as receiver and president until 1911, when he was elected president of the Missouri Pacific Railroad and the St. Louis, Iron Mountain & Southern Railway. He also acted as president of the Denver & Rio Grande & Western Railroad from 1912 to 1915, and as president of the Western Pacific Railroad from 1913 to 1915. Mr. Bush was appointed receiver, being elected president when the two railroads were reorganized and merged as the Missouri Pacific in 1917. He served as regional director of the Southwestern region of the United States Railroad Administration. He retired as chairman of the board of directors of the Missouri Pacific Railroad in 1924, although he remained a director until his death.

New Publications

Books, Bulletins, Catalogues, etc.

Methods of the Chemists of the United States Steel Corporation for the Sampling and Analysis of Gases

Published and sold by Carnegie Steel Company, Bureau of Instruction, Pittsburgh, Pa. Price $2.00.

This book is the result of more than two years' work of a special committee composed of chief chemists of the subsidiary companies of the United States Steel Corporation. The book is divided into four parts dealing with different phases of gas work as follows:

The first part is devoted to apparatus, reagents and absorbing solutions. In it are found a brief discussion of the sources of error in gas analysis, a detailed description of the construction, operation and care of the new apparatus adopted, and a section on the preparation and properties of reagents and solutions used in gas analysis. The apparatus is of the Orsat type, but it is distinguished by a number of new and original features, chief among which are the absorption pipettes. These pipettes are of the bubbling type, but instead of the three-way stopcock required on the older forms, they contain a glass float valve which automatically opens and closes as the gas is drawn out or forced into them. The elimination of the stopcock makes these bubbling pipettes interchangeable with contact pipettes. They, therefore, overcome the objections formerly applicable to bubbling pipettes and offer all the conveniences of the less efficient contact pipettes filled with glass tubes.

Other valuable features of the apparatus consist of a manifold with special 3-way stopcocks, which permit the elimination of all dead space in the capillary tubing; a non-shatterable glass shield, which protects the operator from danger of injury in case of accidental, premature, or too violent explosions; an improved manometer, which eliminates the troubles heretofore experienced in the use of compensator attachments; and improved adjustable supports for both the pipettes and the burette, which make it possible the insert new parts and support them in their proper positions without trouble due to variations in the dimensions of glassware. The supports for both the burette and the pipettes are built into the same frame, which is wholly self-supporting, so that the apparatus can be moved about from place to place without disturbing any of the connections. Besides a compensating burette and six absorption pipettes the apparatus is equipped with a slow combustion pipette, an explosion pipette, a copper oxide tube, and if desired, a special burette for the analysis of mine air. This equipment permits the use of different methods of analysis and makes it possible to analyze with accuracy any gas met with in industrial work. All equipment for carrying on combustion is electrically operated and all connections are made by plugging into a single electric lamp socket.

Under the heading of absorbing solutions and reagents, practically all these substances heretofore used for gas analysis are discussed, and two new absorbents of exceptional merit, one for carbon monoxide and the other for oxygen, are decribed.

The second part deals with the sampling and the analysis of industrial gases with the apparatus described in Part I. Detailed directions are given for the sampling and analysis of flue and chimney gases, blast furnace gas, producer gas, by-product coke-oven gas, coal gas, blue gas, carburetted water gas, natural gas, mixtures of natural and coke-oven gas, mine air, and compressed, or cylinder, gases.

In this section a special portable apparatus for the analysis of flue and chimney gases is described. This apparatus employs the same pipettes and the same style of manifold as the laboratory apparatus, and is distinguished for its conveniences, simplicity of construction, compactness and lightness. It is equipped with an aspirator bulb so that connecting tubing may be flushed and samples drawn directly into the burette and analyzed at once.

In the case of all the gases treated of in this part of the book the methods of sampling and analysis are preceded by a brief discussion giving the composition of the gas and citing other points which may enable the operator to select the methods of sampling and analysis best suited to his particular conditions.

The third part deals with miscellaneous determinations that cannot be made with the regular gas analysis apparatus. In this section are described methods for the determination of hydrogen sulphide, organic sulphur, total sulphur, acetylene, hydrocyanic acid and cyanogen, light oil or benzene, tar and mineral solids, naphthalene, moisture and dust in gases. Methods for determining the heating value and the specific gravity of gases are also included in this section. The calculation of results have been explained with painstaking care to enable the operator to avoid errors from this source, and in the case of the more complicated calculations the explanations have been followed by examples to serve as a further guide to the analyst.

The fourth part deals with the measurement of gases, the calculation of gas volumes under different conditions, and a number of problems presented by the combustion of gases. An appendix, composed of twelve tables, gives the specific gravity, the weight per liter and per cubic foot, the B.t.u. values and the specific heats of gases under the standard conditions selected, the properties of water vapor, factors for the correction of observed calorimeter readings, and a long list of conversion factors. These tables supply the data, other than that obtained from the analysis or necessary measurements, for making all the calculations usually required in gas work.

The book is more than a description of methods. It emphasizes the importance of accuracy and recognizes the fact that accuracy is not to be obtained in every case by a blind following of directions. It contains a great deal of information on the sampling, analysis, measurement and combustion of gases, which makes it a work of interest not only to the chemists, but also to combustion and efficiency engineers, students, and, in fact, any one interested in the combustion and handling of fuels.

One of the chief benefits derived by the Steel Corporation from this publication, in which the methods of sampling and analysis, as in the case of other publications of the chemists committee, are proven and standardized, lies in the fact that the analytical results from all the plants of the corporation are comparable. Comparable results make possible a study of the value and efficiency of different raw materials, plant equipment and plant operations. In addition the greater degree of speed, safety and accuracy obtainable by the use of the new gas apparatus, with its many original features, stands for closer control of conditions wherever solid, liquid or gaseous fuels are produced or consumed, and thus contributes untold economies which can scarcely be expressed in dollars and cents.

Fatigue of Metals—By H. F. Moore and J. B. Kommers.—McGraw-Hill Book Company, New York. Price $4.00.

This book is to present the important results of experimental investigations of the strength of metals under repeated stress, to review current theories of fatigue of metals, and to describe the apparatus and methods used in studying the subject experimentally. The author of this book have been actively engaged in investigation of the subject and have also drawn on the work of other American and foreign investigators, with the result that their book is a useful review of present knowledge. In addition to the main subject, wood and concrete are discussed and the scanty data which are available on these subjects are given.

Canada's Diamond Jubilee—The Canadian Pacific Railway in connection with the sixtieth anniversary of Confederation on July 1, 1927, the Canadian Pacific Railway has published a beautifully illustrated booklet, entitled "Canada's Diamond Jubilee." The text is by Keith Morris, and describes the growth and development of the Dominion during the last sixty years. Copies can be obtained from the railroad.

The Anthracite Railroads—By Jules Bogen. The Ronald Press, New York. 281 pages. Price $4.25.

This is a history of the Reading, the Delaware, Lackawanna & Western, the Lehigh Valley, the Central of New Jersey and the Delaware & Hudson treated as a unit. The effects upon the company of the economic and financial developments of the time are shown.

Handling Sand, Gravel, Stone and Bulk Materials—The R. H. Beaumont Company, of Philadelphia, Pa., has recently issued a catalog, devoted to the Beaumont cable drag scraper system for handling sand, gravel, stone and other bulk materials. The catalog includes many illustrations of installations and applications of the equipment which including the drive and hoisting mechanisms, are fully described. The Beaumont bin gates are also described and illustrated in the catalog. The newly acquired Beaumont American slack line cableway is also given prominent place in the catalog. Copies can be obtained from company.

Railway and Locomotive Engineering

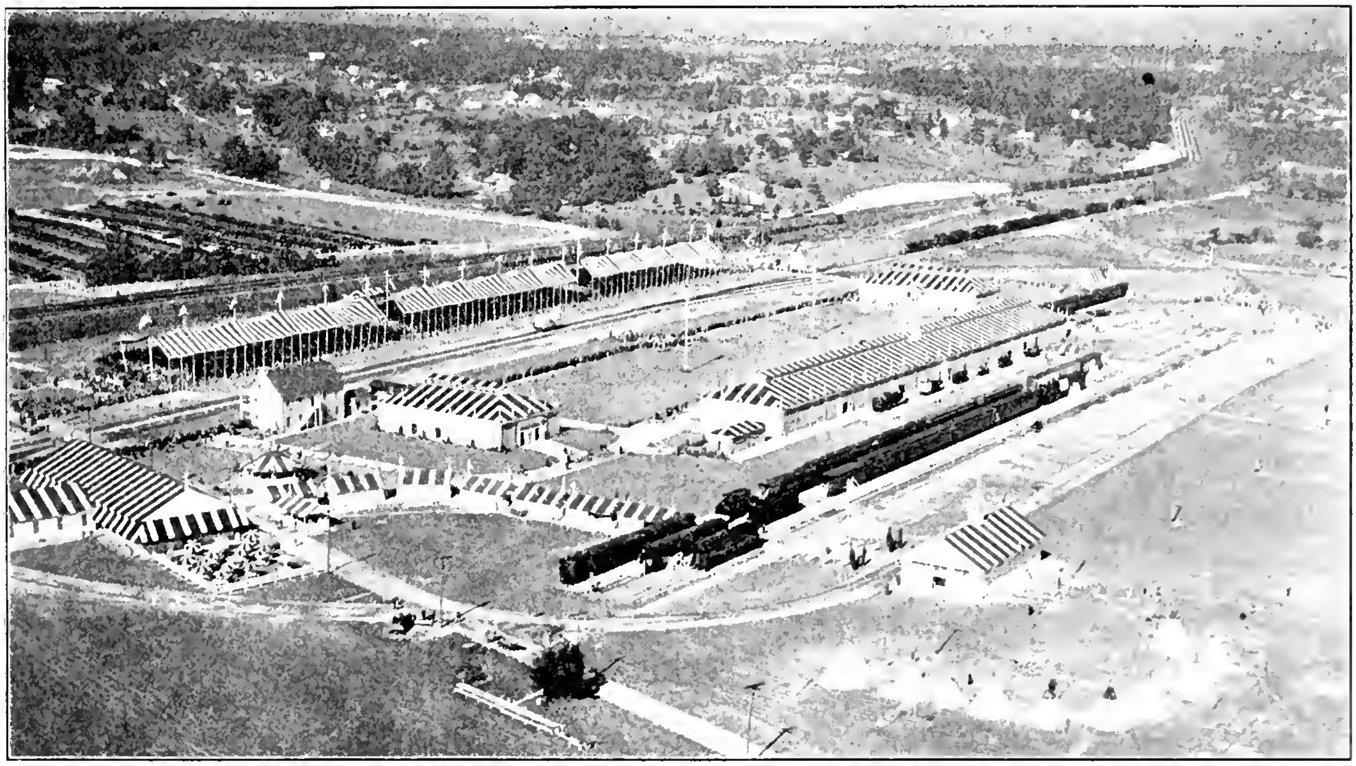
A Practical Journal of Motive Power, Rolling Stock and Appliances

Vol. XL — 136 Liberty Street, New York, September, 1927 — No. 9

The Fair of the Iron Horse

Transportation Achievements Are Shown in Baltimore and Ohio Centenary Exhibition and Pageant.

The Fair of the Iron Horse, the exhibition and pageant of the Baltimore and Ohio Railroad in celebration of the centenary of the company opens September 24th at Halethorpe, Md., a suburb of the City of Baltimore and will continue until October 12th. It is undoubtedly the greatest exhibition showing railroad development that has ever been brought together. Everybody is cordially invited, there being no admission charge of any kind or special invitation required.



Aerial View of the Fair of the Iron Horse Commemorating the Centenary of the Baltimore & Ohio Railroad

The Pageant

Over a loop of standard railroad track more than a mile long and a parallel highway, moves the Pageant of the Iron Horse. It illustrates the remarkable progress made in the development of speed and efficiency of inland transportation during the past one hundred years. It shows in a colorful and elaborate succession of floats and vehicles the many ingenious devices invented to carry passengers and goods quickly and safely from place to place.

At the head of the parade is placed a float called, "America" resplendent in red, white and blue, which carries the Baltimore and Ohio Glee Club, a male chorus of forty voices.

A group of American Indians, with heavily-laden pack-horse and the primitive "travois," pass first in review. The Indians of this group come from Glacier National Park by courtesy of the Great Northern Railway. This part of the pageant is symbolic of early highway travel, crude and slow.

Next comes a float representing Father Marquette, famous missionary and explorer, accompanied by Joliet and two aides, sighting and blessing the Mississippi.

Following this tableau is a float carrying an old-fashioned river bateau, a queer looking boat, pointed at either end, very deep like a dory, and equipped with a crude sail. Then came in order the earliest American road wagon, with a group of early pioneers and their families; the post chaise, which furnished the "fast" passenger service in the early days; and a post rider of the Paul Revere type.

Then follows four floats, depicting the meeting of citizens at which the Baltimore and Ohio Railroad was organized, the laying of the corner-stone of the road, the United States army engineers surveying the line and the horse treadmill car and the sail car. Other features are as follows:

The locomotive "Tom Thumb," the first engine of the Baltimore and Ohio operating under its own steam, and "York," the road's second engine.

Then follows the locomotive "Atlantic" of 1832. This engine continued in service until 1893.

The original "Thomas Jefferson" locomotive of the Winchester and Potomac Railroad, built in 1836.

William Galloway—1837. This locomotive is a replica of the Lafayette, built by Richard Norris, of Philadelphia, and was the first engine with a horizontal boiler to be used on the Baltimore and Ohio. It hauls two flour cars, typical of its day.

Memnon No. 57—1848. Another original locomotive built by the Newcastle Manufacturing Company, at Newcastle, Del.

Two floats depict the first commercial use of the telegraph on May 24, 1844, when the world-famous message, "What Hath God Wrought?" was flashed along the lines of the Baltimore and Ohio from the national capitol at Washington to the railroad station at Baltimore.

Again the scene shifts to the highway and one sees another form of communication in the United States. This is the Pony Express and the early western stage coach.

William Mason—1856. This original locomotive was built by William Mason Company at Taunton, Mass. Mason's beautiful engines were the forerunners of the standard American type locomotives of today.

A critical journey was that of Abraham Lincoln over the Baltimore and Ohio in February, 1861, to his first inauguration. He arrived at Washington in the early morning and is shown with his guards, Allan Pinkerton and Colonel Ward H. Lamon.

Thatcher Perkins No. 117—1863. Designed along the lines of the Mason locomotives but far greater in strength were the ten-wheel engines built by Thatcher Perkins at Mount Clare in Civil War days. The Perkins is painted in its original colors and hauls a passenger train typical of its day.

The camelback locomotive invented by Ross Winans was for many years the most distinctive feature of freight transport on the Baltimore and Ohio. One is shown hauling a typical freight train of sixty years ago.

J. C. Davis No. 600—1875. This locomotive when exhibited at the Philadelphia Centennial Exposition of 1876 was said to be the heaviest passenger engine in existence. It weighs forty-five tons.

A. J. Cromwell No. 545—1888. A very successful consolidation locomotive designed by A. J. Cromwell, a former Master of Machinery of the B. & O.

A float shows the first electric locomotive to operate on a steam railroad. It was run in the Baltimore and Ohio Belt Line tunnel, under Baltimore, and was originally operated by overhead trolley.

No. 1310—1896. The inauguration of the famous Royal Blue Line between Washington and New York called for locomotives capable of high speed. No. 1310 was built for this service. Its 78-inch drivers rendered it extremely suitable for the difficult work it was called upon to do.

Muhlfeld No. 2400—1904. This, the first Mallet ever built in the United States, was designed for the Baltimore and Ohio by John E. Muhlfeld, then the road's General Superintendent of Motive Power, and more recently the designer of the "John B. Jervis" of the Delaware and Hudson Railroad, which is also shown in the pageant.

Various locomotives from other railroads have come to the Fair of the Iron Horse. These now take their place in the procession.

Upon the float is the "Rocket," the famous Stephenson locomotive which made a sensational success at the Rainhill trails, outside of Liverpool, in 1829.

From England there has come the King George V, most powerful locomotive ever built in Great Britain, built by the Great Western Railway at its Swindon shops. The trim lines and simplicity of the engine as well as her color scheme is typical of British railway practice today. It carries neither headlight nor bell.

Another foreign visitor is the "Confederation" of the Canadian National Railways. It weighs three hundred and twenty-four tons and is designed for long runs.

Another Canadian guest is No. 2333, Pacific passenger locomotive of the Canadian Pacific Railway.

Early locomotives of the United States belonging to railroads other than the Baltimore and Ohio are shown and include the following:

De Witt Clinton—1831. The locomotive, with its old-fashioned train, was built at the West Point Foundry in New York City and made her first run between Albany and Schenectady over the Mohawk and Hudson Railroad, now a part of the New York Central system, on August 9, 1831.

John Bull—1831. Among the earliest locomotives imported from England was the John Bull from the famous Stephenson Establishment at Newcastle-on-Tyne. It was placed in service on the Camden and Amboy Railroad, now a part of the Pennsylvania system, on November 12, 1831. The engine and the original coach are ordinarily kept in the Smithsonian Institute at Washington.

Satilla—1860. Built by the Rogers Locomotive Works for the Atlantic and Gulf Railroad, and recently restored by Mr. Henry Ford, who has loaned it to the Fair of the Iron Horse.

William Crooks—1861. The first locomotive to operate in Minnesota, having gone into service from St. Paul to St. Anthony, now Minneapolis, June 28, 1862, with a baggage car and coach.

No. 5205—1927. The "Hudson" type locomotive brought out by the New York Central Railroad in the late summer of 1927, for the haulage of heavy passenger trains at very high speed.

No. 8800—1926. The Pennsylvania Railroad has sent one of its finest high-speed passenger locomotives. The fine design and symmetry of the locomotive is characteristic of Pennsylvania Railroad practice. It was built at the Altoona shops of the company.

John B. Jervis—1927. One of the most radical departures in American locomotive design is the John B. Jervis built by the Delaware and Hudson Company. The outstanding feature of this locomotive is the water-tube boiler, capable of carrying a sustained pressure of 450 pounds to the inch, and designed by John E. Muhlfeld.

No. 1125—1927. A Decapod freight locomotive of the Western Maryland Railroad is shown. The total weight of the locomotive and its tender is 417 tons, and it has a tractive power of 90,000 pounds.

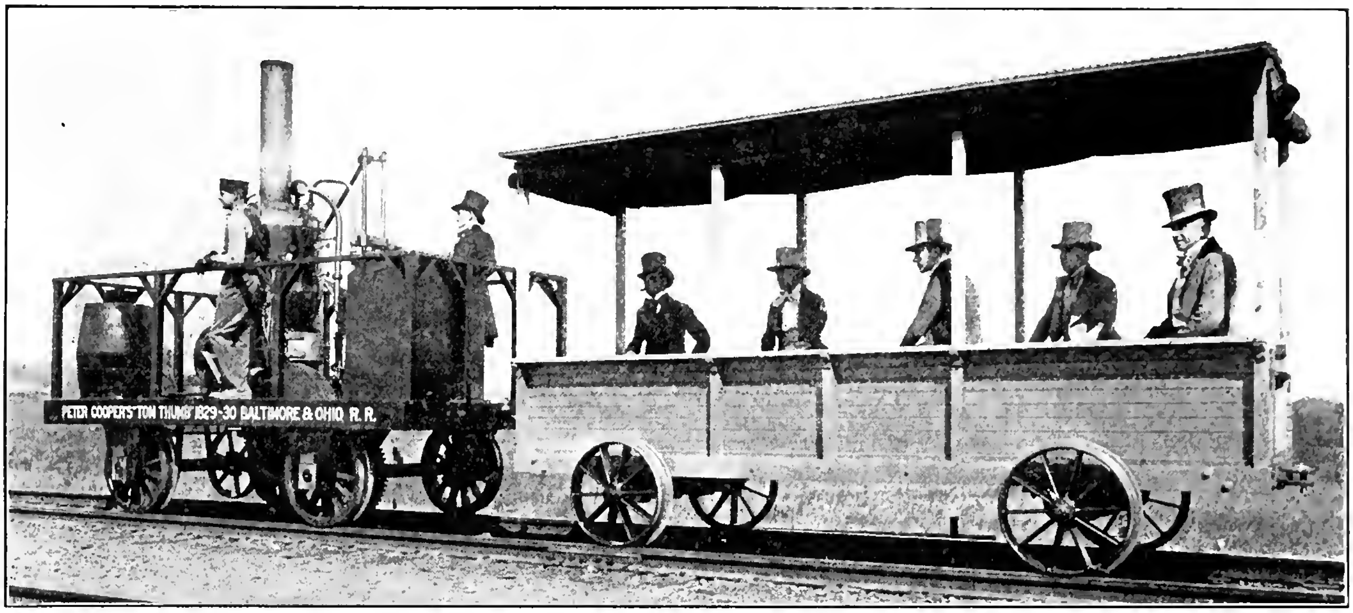
The procession of the pageant closes with an exposition of modern motive power and trains on the Baltimore and Ohio.

No. 2024—1927. This locomotive, designed for local service, has recently been modernized in Baltimore and Ohio shops. It wears the new passenger livery of the road—olive green and black, striped with red and gold.

No. 5005—1924. From the Mikado type has been developed this passenger locomotive, weighing with its tender 150 tons, and having a tractive power of 44,600 pounds.

No. 4465—1920. A Mikado built by the Baldwin Locomotive Works. A freight locomotive weighing 160 tons, with a tractive power of 63,000 pounds.

No. 6137—1926. In recent years the Santa Fe type has begun to replace the Mikado in popularity upon many American railroads. The No. 6137 weighs 367 tons and has a tractive power of 84,300 pounds.



Peter Cooper's Locomotive "Tom Thumb" First on the B. & O. R. R.

Philip E. Thomas No. 5501—1926. Designed and built by the Baltimore and Ohio in its historic Mount Clare shops, the Philip E. Thomas is one of the heaviest passenger locomotives in the world. It weighs 330 tons. Tractive power 68,200 pounds.

Maryland. The final float of the procession depicts Maryland seated with her great seal in hand. At her feet is her fine city of Baltimore with its trains and ships, emblematic of the great commerce that constantly passes through it.

No. 7151 and Freight Train—1919. One of the most powerful engines in Baltimore and Ohio freight service is this simple articulated Mallet with its great tractive power of 118,000 pounds. The short train hauled by this locomotive is made up of but twelve cars, each of them, however, typical of the service for which it is designed.

President Washington No. 5300 and the Capitol Limited—1927. The final triumph of the procession is the beautiful locomotive President Washington, first locomotive of the President class, which made its debut upon the Baltimore and Ohio in this summer of 1927. Resplendent in their olive green coloring, the President locomotives attract universal attention. While they are designed primarily for the New York-Washington service, the President Washington here hauls the famous train—The Capitol Limited—which already has won in its daily trips between Chicago, Washington and Baltimore, a nation-wide reputation for service, comfort and dependability. The six cars shown in the Capitol Limited of the procession represent but half the ordinary length of the train, yet typify each feature of its unusual equipment— from barber shop to observation platform.

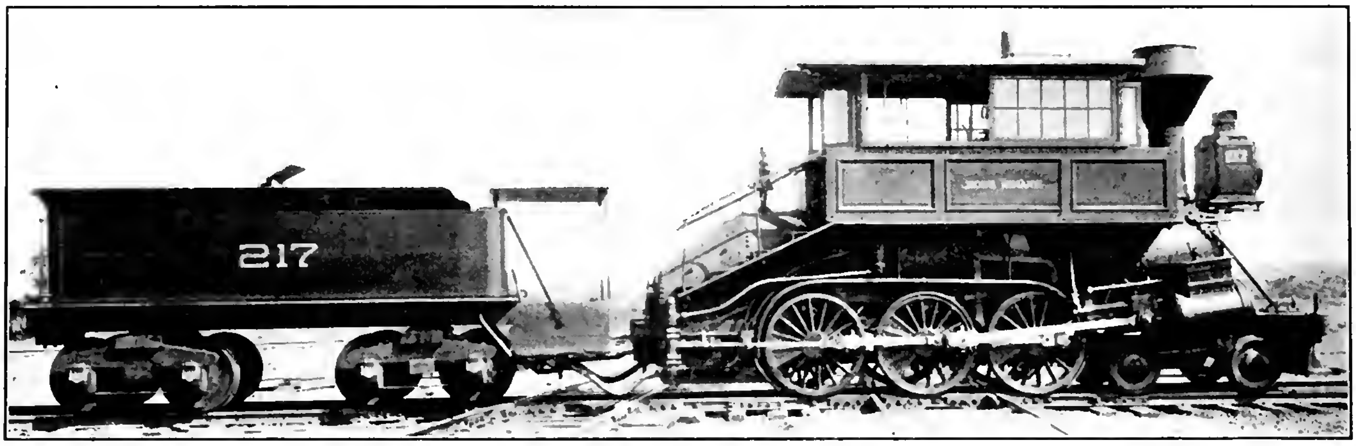
The Hall of Transportation

A Central building, the Hall of Transportation, is 502 ft. long and 60 ft. wide. In this building the largest exhibit is that of 31 full-size models of early locomotives. These fall chronologically into four groups. First, those prior to the nineteenth century; second, those built from 1803 to 1814, inclusive, preceding the definite establishment of the steam railroad as an instrument of public service; third, those built from 1826 to 1837, inclusive, which, with one or two exceptions, actually rendered successful service on steam railroads, and fourth, Ross Winans' "Camel Back" of 1848.

In the first group are Newton's "idea," put forward in 1680, and, although it was never actually developed, it is here concretely illustrated, and the famous "Cugnot," the wild steering of which on the streets of Paris in 1769 is said to have led to the confiscation of the machine. In the second group are seven locomotives, the first of which was the work of Captain Richard Trevithick in 1803, which is credited with being the first locomotive in the world to run on rails; and the last of which is the "Blucher," the first locomotive built by George Stephenson. In the third group are 21 locomotives, with one exception all of English or American origin. The "Seguin," the oldest of the group, built in France in 1826, is the first locomotive in the world embodying the tubular principle of boiler construction. Among the models of American locomotives are those of the famous "Stourbridge Lion" (1829), the first locomotive to run in America, imported from England by the Delaware and Hudson Canal Company; Peter Cooper's "Tom Thumb" (1829), the first American-built locomotive; the "Best Friend" (1830), which was the first American-built locomotive to operate successfully in actual service; the "York" (1831), winner of the Baltimore & Ohio trials; "Old Ironsides" (1832), Matthias Baldwin's first locomotive; the Jervis "Experiment" (1837), in which was made the first application of equalizing beams. Among the English models are the world-famous "Rocket" (1829), the successful performance of which at the Rainhill trials of the Liverpool & Manchester won George Stephenson the title of the Father of the Locomotive.

Two picturesque scenic models, worked out in beautiful detail, are placed on display in conspicuous sections of the Hall of Transportation.

A model 250 feet in length shows typical scenes along the Baltimore and Ohio from Baltimore to Chicago, and illustrates transportation progress from 1827 to 1927. Ten miniature working models of locomotives, old and new, with baggage, freight and passenger cars characteristic of the respective periods, run on this little, reproduced Baltimore and Ohio, depicting the evolution of railroad operation. There are also eleven models of various types of bridges representing different periods. The first section of the panorama shows Baltimore Town in 1830. It depicts the Carrollton Viaduct, a single stone-arch bridge over Gwynn's Falls, the first built by the Baltimore and Ohio in 1829, and the oldest in the world. In the background is shown Baltimore with the familiar landmarks and the Washington Monument and Shot Tower rising above the roofs and trees of the old town of a century ago.



Locomotive No. 217—Ross Winans Locomotive of 1869

In contrast to this is Chicago of today at the other end, presenting the Chicago Terminal of the Baltimore and Ohio in 1927, with the Capitol Limited emerging from it. Between the two extremes the scenes portray the general character of the terrain, the rugged mountains of Maryland and Pennsylvania giving way gradually to the rolling country of Ohio and Indiana.

Another scenic model, 60 feet long, is historic Harper's Ferry and vicinity in 1859, the year in which John Brown conducted his famous raid upon the United States arsenal there. The engine house, which became known as John Brown's Fort, may be distinguished.

The chief feature is the combined bridge of the railroad and highway. The railroad through this bridge, with its sharp curves at both approaches, was long recognized by scientific writers on engineering as one of the most difficult and dramatic bits of railroad location in the world. The historic bridge, some 700 feet in length, was destroyed by Stonewall Jackson in 1861, as he evacuated Harper's Ferry with the Confederate Army, first burning the arsenal.

In attempting to show the American public the greatest collection of historic and modern locomotives, coaches, cars, bridges, appliances and transportation methods ever assembled in America's hundred years of railroading, in the original and by reproductions, models and miniatures, the Baltimore and Ohio has also brought forth from storage its rare collection of locomotive pictures for display.

This collection of locomotive pictures is probably the only one of its kind in the world.

A comprehensive display of railway signaling devices since the first signal of 1834 is exhibited by the Union Switch and Signal Company and the General Railway Signal Company. It shows the development of means for safeguarding and expediting the movements of trains by signals.

Occupying nearly 1,000 square feet of space, the signal display includes drawings and photographs artistically colored, illustrating in chronological order the development of signaling from the crude design of 1834 to the higher perfected instruments of the present day. These illustrations are mounted on ninety large panels arranged in a double row 100 feet in length.

Full-size signals are also shown in operation, representing the four types of present day devices—the semaphore and the three "daylight" light signals, color light, the position light and the color position. In addition, full-size highway crossing signals is demonstrated by the flashing-light and wig-wag types.

The set of illustrations, grouped under thirteen divisions, cover in great detail the various methods used in the controlling of trains by signals. Among these is a historical sketch, in pictures, of signals of fixed location indicating a condition affecting the movements of a train. The purpose of fixed signals is to convey information to the engineman for the government of his train, showing when, where and how to go, and when and where to stop.

Train dispatching or directing and supervising the movements of trains upon which transportation efficiency so largely depends is also demonstrated by photographs.

Other panels show the automatic block system, mechanical interlocking—an arrangement of switch and signal appliances so interconnected that their movements must succeed one another in order to provide a safe path for the movement of trains through switches, junctions, drawbridges, etc.

All kinds of devices, large and small, connected with the development of locomotive and car appliance are demonstrated.

This elaborate display was supplemented from the collections of early patent models owned by the Smithsonian Institute and the Eastern Railroad Association, of Washington, D. C.

Miniature models of early locomotives and cars, as well as of their component parts, are shown in great profusion. Some of the items are picturesque, as, for instance, the gaily colored headlights used upon early American locomotives.

In contrast to the mechanical headlight there is demonstrated an even earlier method of announcing an approaching train at night. This method, although crude, was convincing. It consisted of a flat car pushed ahead of the locomotive and carrying a rousing bonfire, the glare of which was sent ahead along the track by means of a tin reflector. This interesting early device is shown on a half-size model of an early flat car, pushed by a half-size model of the locomotive "Arabian," which came into use upon the Baltimore and Ohio in 1834.

Other portions of the exhibit show the development of still other devices, such as those connected with the rolling stock of the railroad-couplers, steam injectors, platforms, car wheels and similar items.

One section is devoted to hand lamps; a model of the hand lantern used by the conductor on the first train over the Ohio and Mississippi Railroad; one with flat glass and protecting rib; a three-color signal lamp used on English railroads; a signal lamp with adjustable chimney support; and a hand lamp with removable signal glass.

A special water cooler booth shows the history of drinking water systems on the railroad. The exhibit begins with a wooden bucket containing water and ice, wooden top cover and tin cup. Then comes the cast iron double cylinder water cooler, ice and water contained in one compartment, the water drawn by a faucet. Following this is the latest type of drinking water cooler with separate compartment for ice and for water, the compartment for water protected with a double insulated wall surrounding the ice chamber. Finally, there is displayed an individual drinking cup machine and the latest type of cooler, in which water enters a filtering stone first, either under pressure or overhead gavity, and is then discharged into a water container from which it passes into the cooling pan surrounded by ice.

The Locomotive Stoker Company, of Pittsburgh, Pa., has furnished an interesting exhibit, showing the development of firing an engine.

Mechanical Stokers for locomotives have been in use less than a score of years. The Centenary display shows locomotives fired by hand, full-size models of street and Duplex stokers and a one-third size Duplex stoker with boiler, tender and stoker in operation, and a model of a coal pusher.

Another exhibit shows the development in passenger car heating from the days of the wood burning stove to the modern vapor system of car heating.

An exhibit by the Westinghouse Air Brake Company shows the development in power brakes for the control of trains.

The Allied Service Building

The evolution of the telephone is shown by the American Telephone and Telegraph Company. Like several other big companies national and international in their scope, this company's exhibit is one of the main attractions in the Allied Services Building.

Bell's first telephone instrument and the first telephone switchboard, forming one part of this exhibit, are shown in replica. Another portion traces in chronological order the various improvements to the telephone—Bell's box telephone of 1877, the first in commercial use, the wooden case hand telephone, the first rubber case hand telephone, the first attempt to extend the range of transmission, a set of 1887 equipped with long distance transmitter and so on to the present-day type. Pictures are displayed portraying the latest achievements of television, telephotography and transoceanic telephony.

How the telephone plays an important part in railroad operation forms one of the most interesting features. This portion has a train dispatcher's desk, displaying the present methods of operating railroad trains safely by the use of the telephone. An experienced train dispatcher is on duty at his desk, from which wires are strung to a large picture portion of Baltimore and Ohio System on the wall above, here the wires connect with the signal operator at work.

Part of the display is devoted to a museum of express receipts, forms and circulars of instruction used from the inception of express service in 1839 until 1927.

Reminiscent of the days when the carrying of express was an adventuresome and dangerous business, there will also be shown a wooden treasure chest, iron-bound and securely locked, used to carry gold-dust on the early stage coach; a pistol and sawed-off shot gun carried by the express messenger to guard the treasure chest in pioneer days; and the equipment of the twentieth century express messenger in protecting money, bullion, and other valuables while in transit. On tracks outside the buildings are spotted two American Railway Express cars.

One car is of the very latest type for transporting fruits, meats and other perishable products. It is 50 feet long, with a bunker capacity of 11,550 pounds of ice, and a gross carrying capacity of 60,000 pounds. The car contains a floor rack which permits the shipments to be loaded with crushed or lump ice directly above the contents and keeps the water from the melting ice from damaging the portion of the shipments next to the floor. Water from the melting ice finds its way from the bunkers through the drips at the bottom.

The other car is an all-steel 50-foot express coach of 50,000 pounds capacity, in charge of a regular American Railway Express messenger. The car is set up to represent a Baltimore to Cincinnati express messenger car as it is operated every day, so that the manner in which express shipments are handled en route may be readily understood.

The oldest telegraph instrument in the world is being exhibited by the Western Union Telegraph Company.

This old instrument, by which the inventor, Prof. S. F. D. Morse, sent the first telegraph message in the world—"What Hath God Wrought"—from Washington to Baltimore, Md., is one of the chief attractions in the Western Union exhibit, showing the various steps in the development of telegraphy from its inception in 1844 to the present. Rivaling it in interest is the latest cable transmission machine attached to the London cable, over which news can be sent to and from the English metropolis.

The original Morse instrument has long been part of the Smithsonian Institute's collection at Washington.

In contrast to Morse's great discovery is also the Simplex printer by which modern telegraphy covers distance. This instrument might be termed a long-distance typewriting machine, and represents today's method of automatic telegraphy.

The Federal Post Office Department is displaying its activities in relation to the railroads.

Among the features of particular interest is a miniature model of a railway postal car used about sixty years ago, a model of an obsolete type of horse-drawn vehicle formerly used for rural delivery service, an electrically controlled view of the transcontinental air mail route, and an exhibit of the different kinds of mail sacks, pouches and satchels used in the postal service. Two automatic motion picture machines run off several reels showing the different methods of transporting the mails.

A major feature of the postal displays is a regulation 60-foot United States Railway Mail Post Office car, used for the distribution of mail en route.

In a car of this type there are 744 boxes, 4½ inches wide, 4 inches high and 10 inches deep, in which letter mail is separated for distant cities and towns, as well as those along the line traveled by the car, and for connection railway post office cars. There are also ten 5-foot sections of bag rack and ten bridges in which are hung sacks; papers, packages and other bulky matter are separated in these. In addition, this class of mail is separated in the fifty boxes, twenty-five on each side of the car, above the bag racks.

Here also is an exhibit of unusual interest and importance showing in an attractive manner the facilities offered by the Baltimore and Ohio Railroad to its employes to help them acquire their own homes and secure other benefits. This exhibit of the railroad's Relief Department is designed to show the importance of its work in the life of the employes. Charts and illustrations present graphic evidence of what has been accomplished by its relief, savings and pension features.

Steamship Model Exhibit

Eleven steamship companies, representing transoceanic, coastwise, lake, bay and river lines, have joined in the big transportation show by lending models of their most modern and largest vessels.

Altogether this display of the great steamships of the United States complete the general ensemble showing the history and development of railroad and steamship transportation during the last 100 years. The co-operation of the steamship lines in the Fair of the Iron Horse brings out an important chapter in Baltimore and Ohio history, as it was the first railroad to establish a steamship line to Europe, in 1868.

The model of the "Majestic," furnished by the White Star Line of the International Mercantile Marine, is 12 feet long. This vessel has nine steel decks, connected by electric elevators, a crew of 1,000, and capacity for 4,000 passengers.

The "Leviathan," in miniature, has been sent over to the exhibition grounds from the Smithsonian Institute at Washington by the United States Shipping Board. It is the flagship of the transoceanic fleet of the United States Lines.

The "Aquitania," model of the Cunard Steamship Company, Limited, is 5 feet 5 inches long, 15¾ inches wide; and 21 inches high.

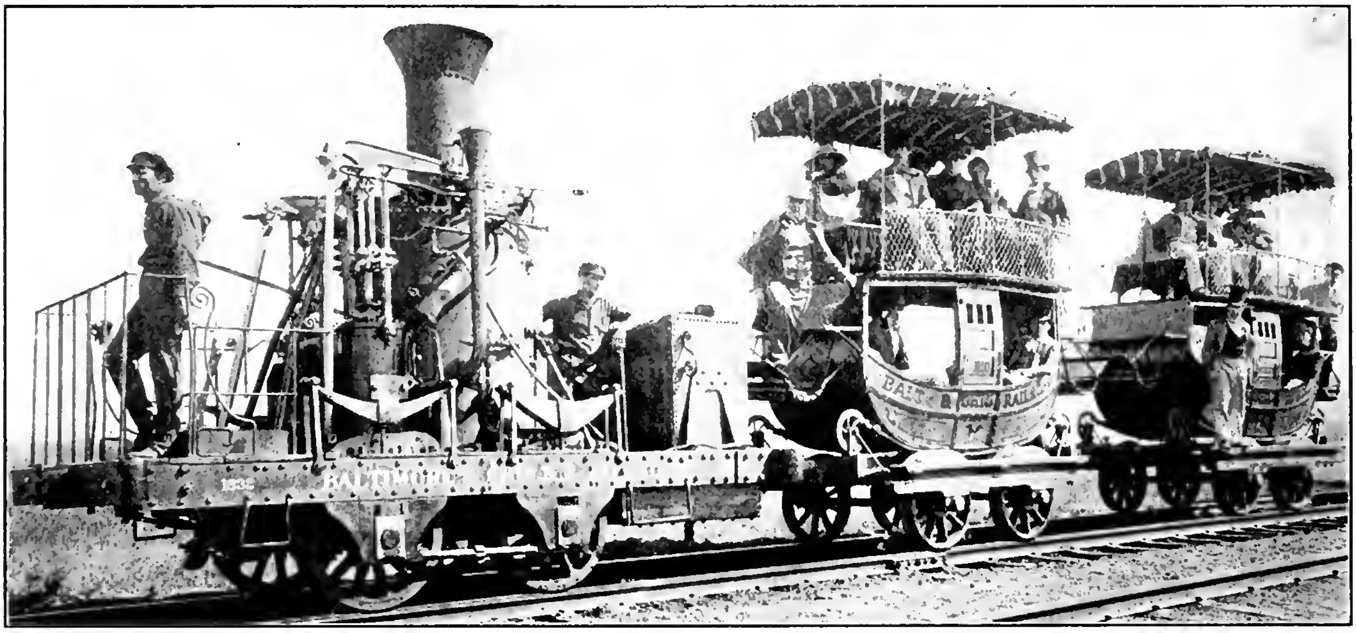
One of the largest cargo liners afloat is represented by a small reproduction of the S.S. "Lewis Luckenbach," the property of the Luckenbach Steamship Company. This model shows not only the exterior outlines, but displays the interior arrangement for stowing cargo. This company has also sent replicas of its piers, offices and railroad facilities at Woodcliff, N. J.

The "Columbus," representing the 774-foot vessel of the North German Lloyd Steamship Company, is among the marvels of the ocean-going lines.

Steamship transportation on the Great Lakes is shown in the model of the "Greater Detroit," the largest side-wheel passenger steamer on inland waters in the world. This is the exhibit of the Detroit and Cleveland Navigation Company.

The Hudson River Day Lines display a contrast between the old and the new, with a miniature of Robert Fulton's "Clermont," the first practical steamboat in the world, and its modern 400-foot vessel, the "Hendrick Hudson."

The Chesapeake Steamship Company displays a topographical relief model of the Chesapeake Bay district.


The Locomotive "Atlantic" and Imlay Coaches at the Fair of the Iron Horse

Showing the latest development in coastwise service, the Merchants and Miners Transportation Company exhibits a model of its "Ontario," one of the largest vessels plying along the Atlantic seaboard.

The Baltimore Steam Packet Company shows a reproduction of its "State of Maryland," one of the big Chesapeake Bay steamers.

The Great Lakes Transit Corporation is displaying a model of the steamship "Octorara," which plies between Lake Erie and Lake Superior ports.

Stationary and Track Exhibits

The track and stationary exhibits include the following:

An agriculture demonstration train. "The General," the historic Civil War locomotive of the old Western & Atlantic, loaned by the Nashville, Chattanooga & St. Louis.

Modern locomotives from the Pennsylvania, the New York Central, and the Western Maryland.

A mine car, running on rails which were flanged, rather than the wheels, antedating by many decades the first attempt at a commercial railway in the modern sense.

The Reading's "Rocket."

An old New England stage coach.

A Washington type stage coach.

An oil tank car.

Several modern Baltimore and Ohio coaches, showing one with individual bucket type seats.

The Pullman Company's first car, which was operated on the Chicago & Alton in 1859. Besides it is a recent product, an "entertainment car," equipped with a moving picture projection room, a gymnasium, a barber shop and a library.

Modern refrigerator cars supplied by the Merchants Dispatch and the Fruit Growers Express.

A glass lined tank car for handling milk.

The first two locomotives in Canada, the "Samson" and the "Albion," and the first passenger car ever used in Canada.

The "North Star," the first locomotive of the Great Western Railway of England, reconstructed for the British centenary celebration in 1925.

Modern Canadian locomotives, one from the Canadian National and another from the Canadian Pacific.

The Cumberland Valley's "Pioneer."

A 60-ton oil-electric locomotive used in switching service, and a rail motor car with trailer.

Maintenance of Way Exhibit

A comprehensive exhibit of maintenance of way equipment and methods is shown. A ballast distributor, designed and patented by W. B. Straw, a Baltimore and Ohio supervisor of track, is one of the principal parts of this section.

Old practices for distributing ballast are exemplified, including the ballast fork of fourteen prongs, the screens against which the stone was thrown and the McWilliams mole. This machine is placed between two sets of tracks and is equipped with caterpillar tread wheels. It is run by a gasoline engine and digs itself along through the ballast. Hence, it was named after the animal it resembles—the mole.

Development in the means of transporting track workers to their tasks is also shown. Starting with the handcar, in use from 1850 up to the Civil War period, there followed the modern pump car and the gasoline-driven motor car.

The tools used for leveling the roadbed are included in this exhibit, from the early tamping bar to the modern pneumatic tamping machine. Photographs depicting modern methods of timber preservation in the tie treating plant of the Baltimore and Ohio at Green Spring, W. Va., and of a rail sawing machine completes the Maintenance of Way section.

Ten sections of railroad track, 30 feet long, so arranged as to give a complete picture in chronological order of the development of rail construction during the past century is among the exhibits outside the main buildings.

The first section shows part of the original main tracks of the Baltimore and Ohio constructed between Baltimore and Ellicott's Mills in 1829-1830. These tracks consist of long "stringers" or timbers of tough yellow pine to which is fastened an iron strap rail, over which the early locomotives ran. The rails used in this section were found holding up the back porch of an old farmhouse in Carroll County, Maryland.

The second section of track is made of rectangular blocks of heavy stone, instead of wood, placed end to end and overlaid with the iron strap rail. This track represents another type of rail used on the main line between Baltimore and Ellicott's Mills in 1830.

The next two sections show improvements made in 1835 and in 1842, although the wooden stringers were still on the lines between Relay, Md., and Washington, D. C., and between Harper's Ferry, W. Va., and Cumberland, Md.

The year 1852 is represented by a section of cross-tie and "T" rail construction as built in the original main track between Cumberland, Md., and Wheeling, W. Va. This rail is of the John Brown or pear-shaped section. It was made of iron and weighed about 60 pounds per yard. This was the first time on the Baltimore and Ohio that rail was placed directly on cross-ties, similar to present usage.

Succeeding sections show the progress made in more modern track construction, as the rails gradually became heavier, stronger and more efficient up to the heavy 130-pound rails aid on chemically treated cross-ties, showing the present standard of track construction.

The Traffic Building

In what is known as the Traffic Building is shown other activities of the railroad, such as the locations of industries on the road and the development work in connection with the agricultural and geological resources along the line.

Here is a model of the Locust Point Grain Elevator, Baltimore, Md., which was first put in operation three years ago by the Baltimore and Ohio to replace two destroyed by fire that had stood for forty years.

By exhibiting a model of this great grain handling machine, it affords visitors opportunity to view at close range the methods employed for the continuous operation of the mechanical units, without interfering with one another. It demonstrates the shipping of grain to vessels loading at eight different berths over a gallery system of 2,500 feet to the most distant berth; also, how the unloading of cars of grain is accomplished at the same time by the use of four automatic car dumpers, averaging eight minutes to a car.

The present capacity of the plant is 3,800,000 bushels, and has a potential capacity of 9,800,000 bushels. Huge washing and drying machines are installed in it for cleaning and protecting the grain.

The Locust Point Grain Elevator model is displayed on a platform in the center of the building, along with other displays showing the co-operative activities of the road.

The Passenger and Freight Departments of the Baltimore and Ohio Railroad Company have assembled a museum of historic data, including time tables, folders, tickets, posters and general advertising from 1830 to the present.

In this exhibit there is a miscellaneous group of railway lanterns, switch keys, badges and souvenirs of events in early railway history, displayed in glass cases.

No passenger tickets nor freight waybills were used in early railroad days. Instead, conductors had manifest books in which they listed the names of passengers and the amounts of cash fares or the kind of freight carried, or the names of shippers and the freight charges.

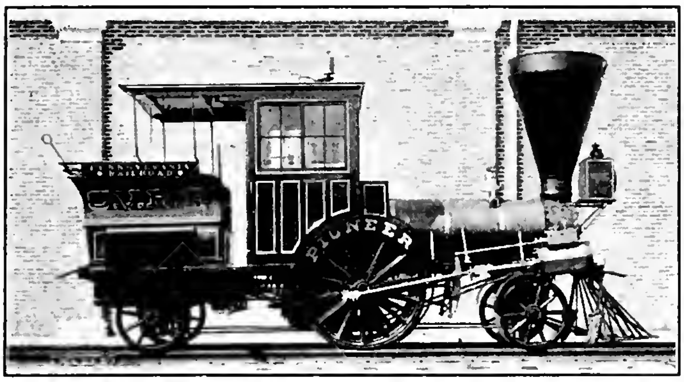
Many of these valuable relics have been loaned for the centenary celebration by descendents of men directly concerned in the building of the railroad.

Particularly interesting is the spade with which Charles Carroll of Carrollton cast the first spadeful of earth at the laying of the first stone of the Baltimore and Ohio, July 4, 1828; also the trowel used in sealing the stone. These have been preserved in the Masonic Temple at Baltimore.

Maryland Pavilion

Interesting exhibits contributed by Baltimore City and the State of Maryland are housed in the Maryland Pavilion, a fair-sized building constructed of wide clapboard painted white, located near the Traffic Building.

The major feature of the State exhibits is a working panoramic model illustrating the construction of a concrete road by the Maryland State Roads Commission, from the laying of the sub-grade to the finished highway. The scene is in the Middleton Valley. A stone crusher, operated by electricity, is shown in the operation of pulverizing material taken from a nearby quarry. A steam roller is seen rolling the first foundation of the road. A little farther on there are men fixing the steel forms for the concrete, and still farther a dumping truck and a concrete mixer. Last comes the finishing machine, which puts the final touches to the concrete highway. The road at one place runs over a stream of real water, filled with small live fish. The scene is at once picturesque and instructive, pointing out the fact that Maryland is the pioneer road builder of the South.



The Locomotive "Pioneer" of the Cumberland Valley Railroad

A display by the Agricultural Department of the University of Maryland shows a large elaborate relief map of the State, made to the scale of one mile to the inch. The whole topographical layout of Maryland is represented plainly and accurately in natural colors. Towns, lighthouses, and other points of interest are illuminated electrically. Red lines represent county boundaries; lavender lines, State roads; and black lines, railroads. Grouped about the large platform on which the map is spread are various farm products of Maryland—vegetables, grains, fruits, and grasses—showing the high quality of agricultural products of the State.

The Conservation Department of the State gives an extremely interesting display illustrating its jurisdiction over the oysters, crabs, terrapin, fish, wild fowl, game, fur-bearing animals and wild life of Maryland. There are specimens of huge oysters, some shown clinging to bottles and boots, some petrified, some taken from the hulls of old ships; confiscated firearms, used illegally; various kinds of tools, such as crab scrapes, patent tongs, and oyster dredges; hard, soft and peeler crabs, some of illegal size, others of the large Chesapeake Bay blue variety; and live terrapins in an aquarium. There will also be pictures showing oyster fleets at work, many types of schooners, and bits of Maryland water scenery.

The State Forestry Department has set up a series of panels demonstrating the value of proper planting and growing of trees, careful logging, and the danger of fire menace. An automatically controlled electrically lighted tableau of a forest fire and contrasting pictures showing poorly managed and well managed sections of woodland are also included in the display.

Among the exhibits of the City of Baltimore is a large detailed layout of the harbor facilities, showing in a bird's eye panorama Locust Point, Curtis Bay, Sparrows Point, and the numerous other key points in the harbor down to Rock Creek on the western shore and Miller's Island on the eastern side.

"General Washington" Tavern

As a headquarters for administrative affairs and representatives of the press, the "General Washington," built in imitation of an old tavern, stands out in quaint contrast among the brick and steel buildings which house the exhibits at the Centenary Exhibition of the Baltimore and Ohio Railroad, at Halethorpe, Baltimore, Md.

Of Colonial design, the building is modeled as exactly as possible after the type of historic inns found along the National Pike in the early days, the social centers of the time. The "General Washington" inn is a two-story frame building 60 feet long and 28 feet wide. It is of wood construction, with the walls sheathed with old-time wide clapboard. The roof is covered with wooden shingles of random widths and thicknesses, giving an ancient appearance. On the front of the tavern is a two-story porch supported by squared posts. Chimneys at either end are of brick and conform to the Colonial style of architecture.

Adjoining the structure is a one-story kitchen, 18 feet long and 12 feet wide, and an old-time carriage shed. These buildings form part of the tavern group and are of the same construction.

The tavern yard is enclosed with a white wood picket fence. Just outside the fence is placed an old wooden pump, with water from the iron spigot emptying into a large iron-bound wooden tub. The general effect is a century-old setting in the present.

An old signboard, with archaic lettering and suspended in front, announces the name of the tavern. The sign shows the bewigged head and scarlet coat of "General Washington."

The first floor of the building is equipped with facilities for newspaper representatives, photographers, and motion picture men.

On the second floor are administrative offices for Edward Hungerford, Centenary Director; T. T. Maxey, Assistant Centenary Director; Mrs. Adele Gutman Nathan, Pageant Director; C. M. Schlesinger, Freight Manager; and John Smith, Superintendent of Installation of Exhibits.

We have endeavored to describe some of the features of this magnificent transportation exhibition. There are thousands of other activities that have not even been touched upon.

Under the direction of Mr. Edward Hungerford plans for the exposition were started several years ago and the work of preparing the fair has been done by the railroad company forces, aided by some outside specialist, such as dramatic directors, etc. The actors in the pageant are employes of the railroad.

The grand stand for the spectators accommodates about 12,000. A pavilion has been provided where visitors to the grounds may obtain food and, in addition, there are a number of refreshment booths, etc. Parking space has also been provided for several thousand automobiles which is in charge of the Baltimore and Ohio police.

Most people take the railroad for granted. At this exhibition of the Baltimore and Ohio Railroad, the first railroad in the United States operated for the public handling of passengers and freight, and its century of eventful carrier, during which its charter nor fundamental organization has changed, the fact has been driven home once more that in the history of nations the railroad, opening up new territory, bringing in populations, creating centers of industry and developing natural resources, has proven to be one of the largest single factors in the world contributing to the welfare and happiness of people.

The English and Metric System of Weights and Measures.

Inadvisability of the Adoption of the Metric System a Plain Business Proposition

Some 60 years ago Congress passed an act of toleration with respect to the Metric System of weights and measures, and since that time the general adoption of the system has had its advocates urging it in the United States.

During all those years the great mass of people who will have to pay the bill have not been clearly informed as to the origin and consequences of such a proposed change in our individual and economic life.

The American Institute of Weights and Measures has been and is now doing an excellent work in placing the matter properly before the American people and in such a manner as to leave no doubt as to where they should stand on the question. It is through the courtesy of the Institute that we are able to quote from a paper on the subject prepared by Samuel Russell of Washington, D. C.

The metric system and the nebular hypothesis were the invention of Pierre La Place, the French astronomer of the period of the Paris Commune. La Place was known for his meticulous concern with infinitesimals. He could see through telescopes and microscopes. Of normal visualization he had none. His notable work was his system of celestial mechanics. His notion was to measure everything on each in terms of the circumference of the earth. He sold his idea to the I. Internationale. And the metric system is the sole relic of the errors of that era.

The Paris Commune decided upon a new standard measure which should equal the ten millionth part of the arc of the meridian which passes from Barcelona through Paris to Dunkirk. They concluded that the quadrant in terms of French toises of fathoms by the standard iron bar known as the toise de Peru was 5,130,740. There are in a toise two French aune or yards and six French pieds or feet. The length of the quadrant in aune or yards was found to be 10,261,480, which the Communist Committee decided to divide into 10,000,000 meters, thus producing a meter equal to 1.02648 aune or yards, which was unlike anything in the heavens above, in the earth beneath or in the waters under the earth. No French or English or other measure were commensurable with it.

But the meter was not defined by decree as the ten millionth part of the quadrant. The meter was defined by the law of 19 Primaire of the year VIII (1799) as the length of 3 pieds 11 lignes and 296 millienes. The fact therefore is that the meter is legally derived from toise and not from the quadrant of the meridian. All that had been accomplished was the arbitrary elongation of the aune or French yard from 36 to 36.9413 pouches or inches.

The Commune ordered a medal to be struck to memorialize the discovery of the prototype taken from nature upon which the uniformity of the new weights and measures was founded. The face of the medal represented a figure of France, holding meter in one hand and kilogram in the other, and carried the inscription, For all time—For all Nations. The back of the medal portrayed a figure, maybe of the man in the moon, with a pair of calipers in his hand, one leg of which rested upon the equator and the other upon the pole under the North Star. This figure carried the legend Unity of measures—ten millionth of the quarter of the meridian.

This briefly is a statement of the attempt to project this theoretical and astronomical notion into the field of practical mechanical and mercantile measures and weights. The notion that the meter is derived or discovered from nature is purely fanciful. The accepted length of the quadrant of the meridian is 10,001,968 meters, which means that the projectors of the metric system were off their base by a mile and a quarter, or by nearly 2 kilometers.

There are in the diameter of the moon 11,420,640 feet. If we divide this great diameter into ten million small diameters, we produce a new diameter of 1.142064 feet, after the same fashion in which the projectors of the metric system produced the meter of 1.02648 yards (aune). This new foot of 13.7 inches would be quite as sensible as the foot of 13.123 inches, produced by dividing the meter as the "world yard" into three parts, as proposed by some metricists. By this means we would have a new lunar standard, quite as natural, scientific and impractical as the astronomical standard of the metric system.

It was the National Academy of Sciences which initiated the propaganda to commit the United States to the metric system. The Academy was incorporated by Act of Congress, March 3, 1863. To all intents and purposes the Academy is a private corporation. The Government has no power to appoint its directors or other officers. It is a closed self-perpetuating body. But it has used government property from the beginning. The Government prints its memoirs and reports. It is one of those institutions which has drawn the government cloak around itself in order to give it the semblance of official authority. At the very first meeting of the Academy on May 4, 1863, a standing committee was set up to propagate the metric system in the United States, and this committee has been functioning ever since. It is this academic committee which has been the instigator of the various attempts to influence Congress to outlaw and penalize the use of the English pound and the inch in this country. Propaganda for metric legislation means this and only this—that it be made a crime to use inch scales and dimensions in American workshops. Unless this can be done the whole metric agitation is foredoomed to failure, and the agitators know it.

Everyone Has Forgotten the Act of 1866

The Act is a forgotten and a dead letter. Outside of the professional metric hobbyists and their bureaucratic coadjutors nobody knows that such an act was passed. The commerce and industry of the country know nothing about it and care nothing about the complicated conversion schedules which are published to educate the public as to the merits of the metric system.

There is but little conversion of any kind in modern mercantile and mechanical practice. The foot, for example, is not converted into yards, fathoms, rods, furlongs or miles, but has displaced these larger units as our general length and distance unit. The inch in the field of mechanics and in the machine trades is used straight in any multiple desired and without conversion into feet. Mechanics today use a 60-inch scale. The notion that American merchants and mechanics will convert pounds and inches into kilograms and millimeters is a metricist dream. There is nothing to it. Congress did not contemplate any such thing. Congress on the contrary, merely provided factors for the conversion of metric units into pounds and inches. But, after sixty years, there is little or no use made of the conversion factors set up by the Act of 1866. There is a little conversion of foreign merchandise from kilograms to pounds, but this is done at 2.2 and not a 2.2046 as provided in the metric act of 1866. There is no market for kilograms in this country. If a person addicted to the metric system, does not want to sell his kilos at 2.2 he can keep his kilos. The approximate pound value of kilo is 2.204622341, the legal conversion pound value is 2.2046, and the actual pound conversion value is 2.2.

English Units Are Independent, Not Metric, Conversions

The pound moreover, is exactly 7,000 Troy grains. The pound is not definitively 453.5924277 plus grams as claimed by the Bureau of Standards. Likewise the gallon is 231 cubic inches. The gallon is not definitively 3.785332 plus liters as claimed by the Bureau of Standards. And the bushel is 2150.42 cubic inches. The bushel is not definitely 35.2383 plus liters as claimed by the Bureau of Standards.

The pound standard does not depend upon any such factors as the temperature, expansion or equation of bars or the calibration of lines. The Bureau of Standards has an authentic platinum pound standards, self-contained and independent of definition in either Troy grains or metric grams. There is no reason why this pound standard should not be recognized and used for what is is, instead of its approximate mis-called equivalent in metric grams. This bureaucratic practice is a mere metric fad for which there is neither reason, necessity, nor utility.

The pound is known the world over. It is better known to commerce in and with so-called metric countries than is the kilogram in the United States. Pound merchandise is bought and sold as such in many metric countries, whereas kilogram merchandise is not bought or sold as such in the United States. Merchandise invoiced in kilograms is entered as pounds in the custom houses, and is bought and sold in pounds in the domestic trade of the country.

The act of 1866 gives the legal conversion value of the gram as 15.432 grains. The approximate grain value of the gram is 15.432356. The actual conversion value of gram is 15 grains. This is the practical factor used by apothecaries for converting grams to grains and drams. The actual pharmacists gram is a quarter-dram or 15 grains. It is thus that custom effectively disposes of impracticable conversion tables.

The yard is 36 inches, it is not definitively 914.40183 plus millimeters as claimed by the Bureau of Standards. There are negligibly few conversions from millimeters to inches in the United States. There is on the other hand, a great deal of conversion of inch dimensions to millimeters in metric countries. Inch dimensions are fundamental the world over in the machine trades. Pound pressures are known and applied the world over—and pound pressures mean pressures in pounds per square inch. It is upon this pressure formula of pounds per square inch that the science of steam engineering has been developed, just as the science of mechanical engineering has been developed by the application of steam power to the propulsion of steel machinery built to inch dimensions. Steel 1 inch thick weighs 40 pounds per square foot. This is a fundamental factor in mechanical engineering. These developments based upon the pound and inch units have been contemporaneous with the progress of modern civilization itself. In this way, pound and inch have been permanently incorporated into the sciences of steam engineering and of mechanical engineering. The pound and the inch are the prime units in the mechanics of the world today.

This is the reason why the conversion of inch dimensions to millimeters is so important in metric countries. These conversions are made by the equation, 1 inch equals 25.4 mm. This factor is not derived from the Act of 1866. It has no relation to the Act of 1866. It is produced by rounding out the millimeter value of yard from 914.3992 to 914.4 which divided by 36 gives an *mm* value for inch of 25.4. If the maximum factor 25.4 be applied to the inch value of meter 39.37 set up by the Act of 1866, it produces a meter of 999.998 millimeters. It has always been known that 39.37 was a rounded-off fraction. It was intended only for commercial conversion. It was not accurate enough for conversions in the mechanical arts. The mechanical arts as practiced in so-called metric countries were concerned not with the conversion of meters to inches, but with the conversion of inches to millimeters. The Bureau of Standards agrees neither with the British nor with the continentals. The continentals have had more regard for the integrity of English measures than has the Bureau of Standards at Washington.

Arbitrary and illegal variation between the English measures and those of the Bureau of Standards has been exploited in great detail by the National Academy of Sciences through its subsidiary, the National Research Council, in International Critical Tables, Volume 1 of which was issued in 1926. Edward W. Washburn, Chief of the Division of Chemistry of the Bureau of Standards, is the Editor-in-Chief of International Critical Tables.

In 1894 Prof. Mendenhall published some tables for the conversion of common linear measures into millimeters, in which these four inconsistent millimeter values for the identical yard extension are set out:

3600/3937 meter=914.40133 mm
Yard =914.402 mm
3 Feet =914.403 mm
36 Inches =914.4036 mm

The Mendenhall Yard of 914.402 mm produces the Bureau of Standards' inch of 25.400055555555555555 ad infinitum millimeters, and it is of this runaway repetend that the metric bureaucrats would make an "exact" definition of the United States inch!

Our commercial capacity measures are not the same as the English. In 1826 the British parliament adopted the Imperial gallon, which is the measure of 10 pounds of water. We have the same pound as the English although the English use a 14-pound stone, a 112-pound hundredweight and a 2,240-pound ton, whereas we buy and sell by the 100 pounds and the 2,000-pound ton. By the same token we should have the same fluid ounce as the British, that is the ounce measure of water. It would then make no essential difference that the English call 160 ounces a gallon and we may call 16 ounces a pint or that we may measure and sell fluids by the 100 ounces, while the English measure and sell fluids by 40-ounce quarts.

Parliament has abolished the Imperial bushel in the United Kingdom. The American bushel of 1¼ cubic feet is now the international bushel used in the grain trade throughout the world.

Modern World Demands Units, Not Fractions or Conversions

The pound and the inch, as also the foot and the ounce, are independent units, each having special utility in its own field. The merit of these four units does not exist in their correlation by the factors 12 and 16, but in the utility of their respective magnitudes. They are the heritage of Imperial Rome to the modern world.

What virtue would there be in putting in a system of kilopounds, hectopounds, dekapounds, centipounds, decipounds and millipounds? Or what virtue would there be in writing 10 pounds as 1 tenpound or 1 dekapound, 100 pounds as 1 hundredpound or 1 hectopound, 1,000 pounds as 1 thousand pound or 1 kilopound, or a ton as 2 kilo pounds? The metricists think that there would be some virtue in calling a $10 a dekadollar, $100 a hectodollar and $1,000 a kilodollar. If we want to anglicize this metric scheme all we need to do is to write $10 as 1 tendollar, $100 as 1 hundredollar, $1,000 as 1 thousandollar, 10 cents as 1 tenthdollar, 1 cent as 1 hundredthdollar and 1 mill as 1 thousandthdollar. Arithmetic itself deals decimally with units, with any unit, and that is all the decimalization we need. To avoid fraction, either common or decimal, it is only necessary to use smaller units. The modern counting, computing, compounding and constructing world distinctively demands units. It avoids both conversions and fractions. There is nothing of peculiar merit in the decimal scheme of the metric system.

Hilgard made no pretense that the Act of 1866 had changed the measures of the United States. He in fact asserted the contrary. It remained for Professor Stratton, the first Director of the Bureau of Standards to do that. Professor Stratton knew of the discrepancy in the Mendenhall order as to the value of the yard and the fact. He knew that this discrepancy was not negligible. He decided to ignore it. It was he who invented the bureaucratic formula, the yard is "exactly" 3600/3937M. This formula as definitive of yard has no warrant in law or fact. It rests alone upon the ipse dixit of Professor Stratton. This is what he taught the personal of the Bureau of Standards. They believed the Professor. They did not know any better.

Now bureaucrats cannot change laws, nor can they change facts. If they be scientists they may discover facts. But the bureaucrats of the Bureau of Standards lived in a false world of their own creation. They refused until recently, to talk the industrial language of the United States. When the merchant said pound they would say 453.592 grams, when the mechanic said inch they would say 25.4005, etc., millimeters.

The professional scientist who sees nothing but the numbers 1 and 10, 10 and 100, 100 and 1,000, 1,000 and 1,000,000,000 is a pseudo-scientist. The vibration ratios of tones in the octave on either the diatome or chromatic scales, the vibration relations of tones in a harmonic chord, the atomic weights of the elements, the specific gravities of substances, the proportion of the elements in chemical compounds and many other scientific data cannot be expressed in decimal numbers. To indulge in the notion that common fractions may be abrogated is as irrational as to indulge in the notion that common multiples or common numbers themselves may be abrogated. The indulgence of such a notion is utterly unscientific. When we come to the field of architecture, mechanics and engineering this notion is obviously preposterous.

The Bureau of Standards is the only place in the world where 39.37=39.370113 is accepted as a true equation. This means that a unit in the first member equals 1.000003 units in the second member of this quasi-equation. By this queer variety of bureaucratic mathematics, inch, foot and yard in the Bureau of Standards are equal respectively to 1.000003 of the common or English inch, foot or yard. This is the sole support of the clamor of the metric lobbyists that the measure of the United States are different from those of Great Britain.

The Bureau of Standards has been overtaken in intricacies of its own contrivance. The Bureau does not know today what the inch, the foot, the yard or the mile is in absolute terms or by any ultimate standard. The Bureau will never get straight on this question until the metric system is kicked out of the picture as far as it having any generic relation to the common measures of this country is concerned. Circular No. 47 of the Bureau issued in 1917, is the limit of this metric nonsense. Pages upon pages of tables are given to such inanities as the conversion of acres to hectares, of bushels to hectoliters and of miles to kilometers under the illusion the publication of such stuff served the industries and economy of the United States.

The Bureau of Standards cannot hide behind the Act of 1866. The Act of 1866 set up no metric values for the pound or for the inch. The act did not mention yard, much less set up a metric definition for it. The act stated the millimeter as .0394 inch, a value which is not accepted by the Bureau of Standards. The Act of 1866 defined the kilogram as the weight of the cubic decimeter of water, the kilogram accepted by the Bureau of Standards and constructed since the Act of 1866, is known to be 27 milligrams heavier than the kilogram defined by the act. The liter recognized by the Bureau of Standards exceeds by the cube of ⅛th inch the liter defined by the Act of 1866.

The Bureau of Standards does not accept the pound value of kilogram set up by the Act of 1866. On page 6 of Circular No. 47 it is said:

"The customary weights derived from the international kilogram are based on the value 1 avoirdupois pound = 453.3924277 grams. *This value is carried out further than that given in the law,* but is in accord with the latter as far as it is there given."

This gram value of the pound is not derived from the pound value of the kilogram stated in the Act of 1866, but is the gram value of the pound as found years after the Act of 1866 was passed.

Why, one is constrained to ask, has the Bureau of Standards, taken the gram value of the pound as found by the International Bureau and refused to take the millimeter value of the yard as found by the International Bureau? If there is an answer that does not involve an ulterior metricist motive it would be interesting to know it.

It is a reflection upon the country, the Government and Congress that metric propagandists have been allowed to get away with this bureaucratic buncombe for all these years. It is encouraging to know that the present Director of the Bureau of Standards for the sake of uniformity wants to wipe out these alleged differences between the common measures of the British Realm and the United States.

There is but one way to uniformity in the field of weights and measures the world over, and that is to return to the basic weights and measures of the Romans assimilated to the English standard.

Why We Should Keep Our Present System of Weights and Measures

Once a dual system is imposed on the country it will become necessary for every man in trade and industry to readily translate figures expressed in one system into figures expressing the same value in the other system. To do this conveniently conversion tables will be necessary.

The statement has been made that it would be a simple matter to place before the farmer, the trader, the artisan, the housewife and others a little table showing the value of similar units to help them in their daily transactions.

Such tables of equivalents have been prepared by the Bureau of Standards and are found in its circular No. 47. While they cover here 45 pages printed in small type, together with 4 pages devoted to the conversion of units, they are far from being complete and not a single table is found dealing with compound units.

A fair sized book, not a "little table," would be required to deal properly with this subject. Such a book, while convenient for scientists, mathematicians and engineers, would be of little use to the average person, who would only be confused in trying to use it. The penalties imposed by a dual system would be felt by everybody.

The Cost to Industry

There are two interpretations of the phrase: "adoption of the metric system."

1. Adoption by the simple process of applying metric nomenclature to English standards, making no change in present sizes and dimensions—a method known as the "metric equivalent scheme." It is impracticable and tending to confusion. Let us illustrate.

If the names of all the streets of the City of New York were changed—the streets themselves remaining exactly as they are—it might be said that the cost of making the change would be confined to altering the street signs. But the confusion, delays and lost motion resulting from such a change of names only would total an enormous sum in cost.

2. Adoption by discarding our present system entirely and re-standardizing to metric sizes and dimensions, becoming fundamentally metric in the same sense as France and Germany are metric.

The complete and unqualified replacing of our customary English units of Weights and Measures by the units of the metric system is the only logical definition of the term "adopting the metric system."

Based on this proposition manufacturers were asked to carefully prepare estimates covering such costs for mutual enlightenment and comparison. The results surprised the investigators. Thirty-one detailed estimates were tabulated and the summary of the information thus gathered is briefly stated as follows:

Aggregates cost to 31 concerns	$21,464,688.00
Average cost per concern	715,489.60
Workers employed by 31 concerns......	94,392
Average cost per worker	$227.40

The Cost to the Artisan

The measuring tools used by the artisan in this country are in nearly every case his own personal property. They are graduated to our customary English system and cannot be regraduated to the metric system. A change in system therefore means a replacement of the present tools by a new set.

From the mason and carpenter whose measuring equipment may consist of only a two or four-foot rule to the highly skilled mechanic and tool maker whose tool chest contains a large assortment of devices this replacement cost will run from 50 cents to over $150.00.

A very conservative estimate based on statistical information shows the cost of a change in measuring systems to the artisans of the country to amount to approximately $28,000,000.00. But while this cost is a great burden and will undoubtedly be resented, a far greater burden is laid on the worker by the metric legislator.

With the atisan's inability to rapidly conform himself to conditions arbitrarily imposed upon him his value will decrease, he will suffer and so will his employer. The cost of the tools he must replace is therefore the smallest part of his burden and becomes insignificant by comparison. Thus a sequence of events is put in motion which will react on the country as a whole.

The Cost to the Merchant and Householder

Everybody knows that of the thousand and one commodities sold daily across the counter the great majority are sold according to weights and measures.

The cost of replacement and in some cases regraduation of the necessary devices will run into figures representing amounts impossible to compute.

Only a tape measure and a kitchen scale may be in evidence, but both are useless if we are compelled to change to the metric system.

Multiplying the cost of these two articles, insignificant in themselves, by only one-half the households of the United States with its 110 million of population, we reach a figure of many millions of dollars. Such an expense would be a complete monetary loss because contributing nothing of value to the home.

The Foreign Trade Argument

One of the stock arguments of the metric party for the adoption of the metric system is that it would be in the interest of "World Oneness"; that Great Britain and the United States, the outstanding non-metric countries, should discard the basic system of weights and measures, upon which they have developed their industrial supremacy and adopt the metric system in order to secure world uniformity.

In support of this argument they point to the 37 countries which are claimed to be metric as against the 12 countries in which the English system prevails and argue that the 12 should join the 37 and make it unanimous.

But the trouble with the argument is that the number of countries is not the true criterion. Many so-called metric countries are of small importance. The real test must be based upon volume of production and world distribution. The fact is that the nearest approach to world uniformity has been achieved by non-metric England and America through natural processes, which no amount of compulsory legislation could have made possible.

Transportation

The railroads of the country in affairs mutually affecting them are represented by the American Railway Association, the membership of which stands for a mileage of 310,000, which is practically the total mileage of the United States.

This Association expressed itself on November 24, 1920, as follows:

"Resolved, That the American Railway Association hereby ratifies the action taken by the Engineering and Mechanical Divisions in opposition to the adoption of the Metric System of Weights and Measures to the exclusion of the English or American system at present in general use and desires to express its hearty approval of the effort which is now being conducted to combat the propaganda being waged throughout the country urging the enactment of legislation whereby the Metric System would be made the sole standard of weight and measure."

The following expressions by some well known educators in touch with the requirements of our people carry weight and conviction:

"I feel that college men who have had no experience outside of the college and laboratory perhaps do not appreciate the situation regarding matters of weight and measurement. It is the manufacturers who come up against the real tests. Having had wide experience as an engineer, manager of industrial plants and as a consulting engineer, I feel that I am competent to look upon the practical side and my opinion is without qualification that a compulsory law in favor of the metric system will be a fatal mistake and would place upon the industrial interests of the United States a tremendously heavy and unnecessary burden which would at this time in view of foreign competition be particularly inexpedient. It would involve the expenditure of millions and millions of dollars and instead of helping us with regard to exports, it would be hurtful.

"To representatives of educational associations and institutions who may have been led into an endorsement of the metric program, I would say that while naturally appealing to the workers in the laboratory as I am in a position to appreciate, I feel sure that to make a metric law compulsory would be a great misfortune to this country."

Dr. Alex. C. Humphreys,
Pres. Stevens Institute of Technology.

"My college enthusiasm for the metric system did not survive my employment as an engineer in Germany, the chief metric country: I found that the metric system was not in universal use there after a generation of compulsory legislation and also found the use of the metric system of no advantage in engineering computation.

"Further careful study for years has convinced me that the fancied logical advantages of the metric system are illusory, and that the agitation in favor of its adoption is harmful to American industry and to engineering education."

Thomas E. Butterfield,
Associate Prof. Mechanical Engineering,
Lehigh University.

* * * *

"There is, I believe, a mistaken feeling that college officials and professors can be expected to favor the metric system and urge its adoption in this country to the exclusion of our established system of weights and measures. Such a feeling may exist among those who have not had practical manufacturing experience but on the part of professors of mechanical engineering and those who are familiar with the needs of our factories, I believe there is a strong sentiment against a change. Further, I feel that it is distinctly hurtful to instill into the minds of college students ideas favoring a change in our basic standards which later experience in practical work makes it necessary to revise.

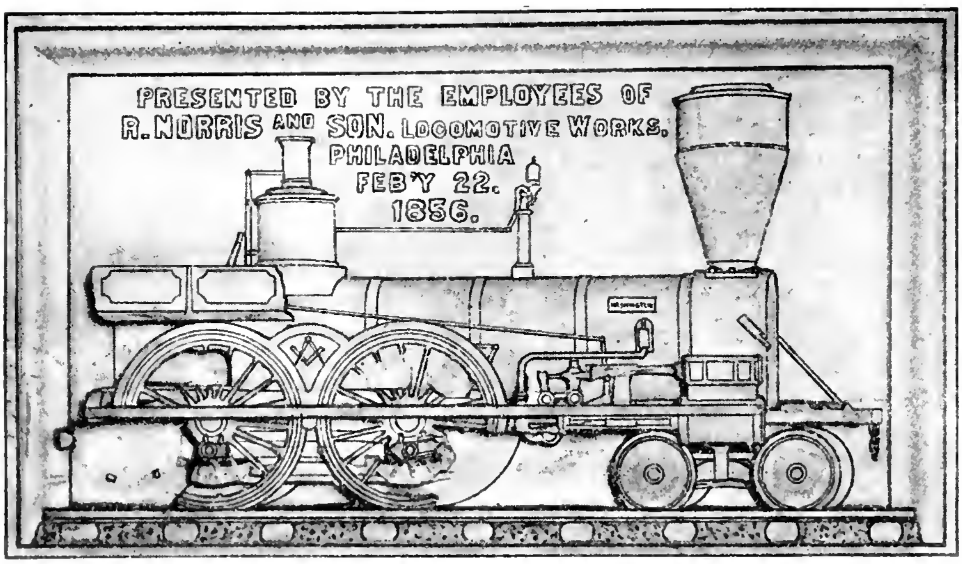
"Colleges and universities should make every effort to co-operate with manufacturers instead of promulgating radical ideas which will 'throw a monkey-wrench into the wheels of industry.' "

L. P. Breckenridge,
Prof. Mechanical Engineering, Yale Univ.

The Norris Locomotive Works Stone of the Washington Monument

By J. Snowden Bell

A stone, five feet six and one-half inches in length by three feet four and one-half inches in height, upon which is sculptured a well executed representation, in relief, of a locomotive of the period, was presented by the employees of the locomotive works of Richard Norris & Son, Philadelphia, Pa., to the Washington Monument Association, then in charge of the erection of the Washington National Monument, at Washington, D. C., on February, 22, 1856. The stone, which is located at the 270-foot landing of the monument, is shown in the accompanying illustration.



Sculptured Stone In the National Washington Monument, Washington, D. C.—Presented by the Employees of R. Norris and Son

Before being forwarded to Washington, the stone, which was then in perfect condition, was on public exhibition in Philadelphia, and the writer, who saw it there, remembers that it attracted much attention and admiration on the part of those interested in locomotive building. It will be observed, from the illustration, that the stone has been seriously mutilated, and the records of the Department of Public Buildings and Public Parks of the National Capital, which is now in charge of the Monument fail to disclose what caused the mutilation.

An examination of the list of memorial stones presented by various States, institutions, societies, and individuals, for insertion in the walls of the Monument, has been made by the Director of the Department, and no record has been found of the presentation of a stone by any other locomotive builder. The stone of the Norris Works is interesting as a memorial of that establishment, which, while one of the earliest and most active during its existence, did not continue in business very long after the date of presentation of the stone.

Railroads Report Fewer Employes

Class 1 railroads reported a total of 1,821,490 employes as of the middle of June, 1927, a decrease of 12,131 as compared with June, 1926. The total compensation paid this June, however, showed an increase of $2,014,224 as compared with June last year.

These figures are taken from a report by the Bureau of Statistics of the Interstate Commerce Commission.

The largest decrease in employment during June this year was in the department of maintenance of equipment and stores, which showed a decline of 23,694 employes as compared with June, 1926. This decrease, together with those shown in other groups, was partially offset by an increase of 24,147 in the maintenance of way and structures department and a slight increase in the executive department.

Railway and Locomotive Engineering

A Practical Journal of Motive Power,
Rolling Stock and Appliances

Published Monthly by
ANGUS SINCLAIR COMPANY
136 Liberty Street, New York
Chicago Office: 168 North Michigan Avenue
Telephone Rector 0746. Cable Address "Locong." N. Y.

Harry A. Kenney, Prest. and Man. Ed.
W. E. Symons, Associate Editor
J. Snowden Bell, Associate Editor
Thomas P. Kenney, Secretary

LONDON REPRESENTATIVE
The Locomotive Publishing Company, Ltd., 3 Amen Corner, Paternoster Row, London, E. C., England.

SUBSCRIPTION PRICE

$2.00 *per year,* $1.00 *for six months, postage paid in the United States, Canada and Mexico. For other parts of the world,* $2.50. *Single copies,* 20 *cents. Remit by Express Money Order, Draft, Post Office Order or Registered Letter.*

Mailing address can be changed as often as necessary—always give old and new address, and if you subscribe in a club, state the name of the agent.

Please give prompt notice when your paper fails to reach you regularly.

Entered as second-class matter January 15, 1902, at the post office at New York, New York, under the Act of March 3, 1879.

Exhibitions That Pay

It is, no doubt, safe to say that a majority of industrial expositions, county and state fairs, homecoming carnivals, pageants, etc., from a strictly financial standpoint, represent a loss or out of pocket account to those responsible for them and who foot the bills. However, the beneficial results of such things may and sometimes do actually justify the cost.

Among the latter and standing at the head of such institutions is the Fair of the Iron Horse of the Baltimore and Ohio Railroad, which depicts in fixed and pageant form the centenary of progress of that railway from 1827 to 1927.

The fixed or stationary exhibits cover completely not only the development of the steam locomotive over a period of 100 years, but includes also a great mass of otherwise useful information identified with the subject of rail transportation, while the pageant simply surpasses anything of the kind ever produced in this or any other country, both in its attractively brilliant portrayal of historical events and its very great inherent educational value.

The Baltimore and Ohio Railroad is to be congratulated on this wonderful exhibition, which so far surpasses anything of like character that we have ever witnessed, that we intrude the suggestion that other leading railways and industrial concerns co-operate with the B. & O. in providing a place for perpetuation and probable enlargement of this magnificent display. It is also within the range of possibility for the Interstate Commerce Commission to become interested in its preservation.

No matter what the exhibition cost, it may be said without fear of successful contradiction that the Fair of the Iron Horse will yield a handsome return on the investment.

The Metric System

Elsewhere in these pages there appears an article on the metric system of weights and measures which we commend to the careful consideration of all those interested in engineering progress.

It would seem superfluous for us to attempt to amplify the plain cold facts that are so plainly brought out in the review of the subject referred to and which deals with both the practical and scientific sides of the subject. The rather definite conclusions arrived at by certain educators dealing with the scientific angles of the matter seem to leave no doubt as to the inadvisability of any change from the established system in use in this country.

As we see it, the American Institute of Weights and Measures is doing an excellent work in exploding some of the fallacious theories advanced by the advocates of the adoption of the metric system of weights and measures.

The Cost of Motor Bus Transportation

Much has been written and said about motor bus transportation and its effect on steam railway revenues.

Recent progress in aerial transportation has also been added to the interest of railway men as it may effect future transportation problems.

The present and future prospective growth of the country is, and will be such, however, as to preclude the probability of any well grounded fear of either of these two new means of transportation having an injurious effect on our steam railways' revenues.

Motor truck and aerial transportation will continue to develop and grow, so will the country grow and so will the steam railways. It is safe to predict that the continued growth of the country will be such that all these facilities will be taxed to meet the requirements of the future.

To us it seems that the most important question in all these problems is, "What will it Cost?"—or what is the relative cost and character of the service.

One of the railway lines in New England that has probably done more than any other in the way of substituting motor cars on railway lines, and buses on public highways as an economic necessity, has recently given out some interesting figures as to the costs of such facilities. This company has in operation 68 buses on 1,000 route miles, making 4,000 bus miles daily, and 24 gasoline rail-motor cars making 2,700 miles daily.

The relative cost per mile of steam railway train, gasoline motor car, and highway motor bus is as follows:

Items	Steam Railway Train	Gasoline Motor Car	Motor Bus on Highway
Wages	38.7	23.40	4.547
Fuel	21.7	10.77	3.343
Repairs	50.8	8.33	5.359
Miscellaneous	16.6	1.17	7.171
Dep. Inc. Interest	16.5	15.88	7.243
Taxes and Fees	12.6	12.60	1.265
Total	158.9	72.15	28.955

From the foregoing figures it would appear that the substitution of gasoline motor cars in place of steam trains on rail lines, and supplementing railway service with motor buses on highways, has met an economic condition that would not yield to other remedial measures, usually followed in steam railway operation.

Of course, the gasoline rail-cars and highway motor buses are new, while much of the steam railway equipment is old and consequently in its most expensive period of maintenance or upkeep. Yet, after making full allowance for this feature the saving effected is too great to be treated lightly.

Then again it must be borne in mind that branch or feeder lines that were otherwise threatened with abandonment, may in this manner be preserved for the communities they serve, while highway motor bus feeder lines may be built up where the construction of a new steam railway line would be out of the question.

It will be interesting to watch the future growth of gasoline rail-motor cars, highway motor buses and also air lines as auxiliaries to our steam railways.

Blessings in Disguise

In the great army of pessimists are those who first predicted the elimination of the steam locomotive by electric power, and later by the gasoline motor-car and motor bus. Now that the airship has been added to the transportation agencies it must appear strange to some of them that the steam locomotive continues to lead the van in the transportation field.

As a matter of fact the introduction and successful operation of motor buses in competition or cooperation with steam railways have in many instances proved helpful or beneficial to the latter, rather than a detriment.

In order to better illustrate this point we may refer to two important lines in the Eastern District. One of these lines, a heavy freight carrier with a small percentage of passenger business, reported a loss of $1,000,000 in passenger receipts, ostensibly due to motor bus activity. The other line, which has a heavy passenger traffic, reported a shrinkage of more than $20,000,000 in passenger receipts as compared to previous years when there was no motor bus competition.

The above statement on its face alone looks bad for the steam railway, but, when we came to look farther into the facts and found that these two lines and numerous others with similar experience, enjoyed the most prosperous year of their existence, with the greatest gross and net earnings in their history, we then are forced to the conclusion that possibly the motor bus may be, and not infrequently is, a blessing in disguise.

Let us take traveling salesmen of whom there are thousands who have taken to motor buses for travel or use their own cars, which means they make two or three times the number of towns per day that could be possible with passenger train schedules—and what is the result? For every dollar of passenger fare lost by the railways, they probably gain ten dollars in increased freight revenue due to the simple fact that the salesman has *increased* his efficiency as a salesman about 300 per cent and correspondingly reduced his percentage of lost time when sitting around local stations waiting for train connections.

Any railway company that will not welcome the opportunity to trade *one dollar* of passenger revenue for *ten dollars* of freight revenue is in pretty bad shape at headquarters.

In the State of Minnesota last year motor buses carried 12,002,648 passengers, with a revenue of $4,626,619 or about 33 cents per passenger.

The number of buses in operation was 402 and the mileage made was 17,327,736 over routes totaling about 4,870 miles.

The seating capacity was about 9,440 persons and the average usual revenue per bus was about $11,509 gross.

Yet the steam railways of Minnesota enjoyed a most prosperous year in 1926.

Railway Efficiency Steadily Increases

Railway efficiency is steadily increasing according to a review of operation in 1926 which has just been made public by the Department of Commerce. In a discussion of railway performance, the Department states that during 1926 the concerted effort to handle traffic without delays continued and all requirements for cars were met without car shortage. There was an average daily surplus or never less than 134,000 cars in any quarter, while the percentage of unserviceable equipment was lower than in the three preceding years.

As compared with the ideal goal of reducing unserviceable freight cars to 5 per cent and unserviceable locomotives to 15 per cent, the carriers averaged 7.7 per cent and 17.8 per cent, respectively, during 1925, and 6.5 per cent and 16.6 per cent in 1926.

A great part of the increased efficiency in railway operation has resulted from the cooperation of the shippers and receivers of freight and other groups associated with transportation.

Railway operating efficiency, resulting in rapid and reliable delivery of freight, has been an important factor in the reduction of inventories and the speeding up of business generally. Where two to three weeks were required for delivery of merchandise just after the war, reliable delivery is made today upon a week to 10-day schedule.

The quicker loading and unloading of equipment have aided greatly in the more efficient use of railway facilities. The quarterly prognostications of car requirements obtained from the regional advisory board members have enabled the railroads to determine the kind and amount of equipment necessary for the carriage of seasonal and regularly moving freight.

In the spring of 1923, the chief executives of the principal carriers of the country agreed upon a comprehensive, concerted and cooperative program, "To insure to the highest degree practicable, adequate provisions for the country's transportation requirements." The objective of the executives was to have the right kind of car at the right place at the right time and in proper condition, and to make prompt delivery of the shipments at the point of destination.

Railway efficiency as indicated in the performance ratios has steadily increased since the inauguration of this program. Along with the increase in the speed of the trains, an increase in the ton-miles per train-hour, a decrease in the amount of coal consumed per ton mile, and an increase in the traffic units handled per employe, we find the public cooperative interest and activity through the regional advisory boards speeding up the loading and unloading of cars.

Locomotive Cabs Here and Abroad

By Arthur Curran

Of the many features of locomotive design, one of the most interesting is the cab. On the early motive power constructed in America, the cab was a small affair, though its roof extended back over the gangway and afforded ample protection for all ordinary purposes.

About forty years ago, however, some builders began to apply about the biggest cabs that the engines of the period could carry. During the 90's, this tendency blossomed forth to such an extent that, on some engines, the cab was the most conspicuous feature of design, and out of all proportion by reason of its size.

Careful study has since shown, however, a way to afford proper protection for crews and valuable fittings without making an engine look ridiculous. In this much-needed reform, the Pennsylvania Railroad took a leading part. When, some years ago, the Class K-4-S appeared, observers noticed that the cab was rather short, but of ample width and with a roof extending back far enough to afford sufficient shelter. There was—and is—but one window in each side-sheet; this being enough for outlook and ventilation. In point of fact, the various extra windows in old-time cabs never served any useful purpose, anyway, and were only liable to be broken.

Today, the typical American cab is of much the same design. Few roads bother with big long cabs whose space for the crew is no greater than that of a well-designed short cab. Certainly, the space on each side of the boiler is superfluous, and adds nothing to the comfort of old-style cabs.

On such a big engine as the Decapod of the Western Maryland, which was described in Railway and Locomotive Engineering for June, 1927, the modern small cab looks very neat, and is certainly large enough for all practical purposes. Numerous other instances might be cited.

In Great Britain, the history of the cab has been very different. Starting with a mere wind-shield, or "weather-board," as I believe it was called—it reached rather respectable proportions more than half a century ago; but, for some unknown reason, was abolished in favor of a small metal structure which still persists on some lines.

A cab with two windows in each side-sheet has been standard on the North Eastern Railway—now the London and North Eastern—for many years, and continues to be used on all important classes of motive power throughout that system.

The Southern Railway (England) is improving upon the old designs, and the London, Midland & Scottish has no standards at all, though some of its engines have good cabs.

A very unusual case of indecision concerns the Great Western Railway, which is of such interest as to be worthy of extended comment. This involves an engine named "Earl Cawdor," now in the "Flower" Class, but originally built as shown in the accompanying photograph. As thus built, the engine had a very fine cab, with two windows in each side-sheet and a roof extending back over the gangway. When this locomotive received a standard G. W. Ry. boiler, the cab was removed and a small metal shelter was substituted. In a search for the reason, one man's guess is as good as another's!

It is significant, however, that, with the appearance of the "Castle" Class, an adequate design of cab became standard on the road. In details, this standard cab differs from the one originally fitted to the "Earl Cawdor"; but the ideas back of both are essentially the same.

This cab question is an interesting one because people who know nothing of the subject frequently discuss it with more vehemence than reason. In long runs in bitterly cold countries, elaborate protection may be needed. Most of the locomotives on which I have ridden, however, have been warmer than I considered necessary. The fireman's work—on a hand-fired engine, of course—is not exactly a cool job, at any season. As for the engineman: Excessive heat may cause drowsiness or even illness, and certainly does not make for mental alertness.

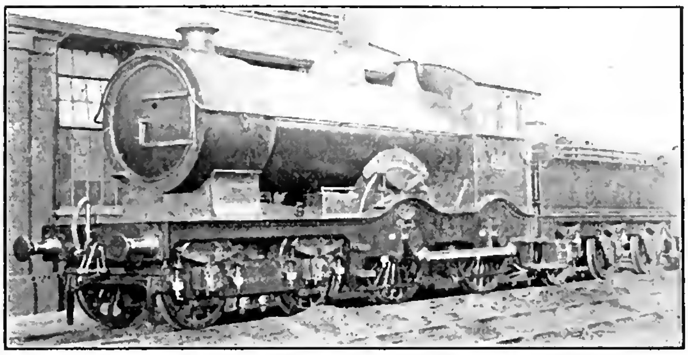
Many old-time British cabs were ridiculously inadequate, from every point of view. Some still are. But there is abundant evidence that the faults of the past are to be corrected in due course.

On the G. W. Ry., enginemen are on the "right side," as in America. Traffic keeps to the left, however; though the arrangement of the "fast and slow" lines is such that this does not always appear to be the case.

Those familiar with American railroad history will recall various instances of left-hand running in this country.

Some British lines still retain the practice of placing control of engines on the left side of cab though the drawbacks of such an arrangement must be obvious, especially as relating to firing of such engines.

The fogs which at times obscure signals on British railways are given as the reason for locating control on left side of cab. Perhaps the location of the signals on some divisions is such as to render this argument valid, though one may be pardoned for doubting it.


Locomotive "Earl Cawdor" on the Great Western Railway of England

However that may be, travel on British railways is remarkably safe, and on at least one line notably fast. And, though some Americans may have wondered whether locomotive cabs were adequate, I do not know of any complaints about them among the men who occupy them. Certainly, the difference in cost between a suitable cab and a poorly designed one cannot be so great as to be prohibitive, either in England or America. Moreover, when necessary cab fittings are dispensed with, and certain others located outside, it is surprising how much room is available even in a relatively small cab.

At all events, the tendency in England is away from the inadequate cab, and in America from the excessively large and cumbersome one. This means that a "happy medium" is the ideal sought on both sides of the "pond."

I. C. C.'s Investigation of Bus and Truck

The Interstate Commerce Commission expects to submit a report on motor transportation to Congress at the opening of the next regular session, the chairman of the Commission, John J. Esch, has stated.

"When we started the investigation last spring it was our hope that we might conclude the matter so as to file our recommendations with the last session of Congress," Chairman Esch said, "but the hearings did not conclude until the 15th of November, and the carriers and all others in interest were permitted to have thirty days in which to file briefs.

"We also sent out questionnaires to all carriers subject to our jurisdiction, asking them to answer numerous questions with reference to motor transportation.

"It was a physical impossibility for us to get ready a report for the last session. The hearings held last summer and fall covered the entire country and made a record of over 5,000 pages. Over 400 witnesses appeared before us, presenting over 400 exhibits. We expect to be able to file our recommendations for consideration by the next Congress."

Convention of Traveling Engineers Association

Reports on Locomotive Utilization and Value of Back Pressure Gauges and Limited Cut-off.

At the sessions of the annual convention of the Traveling Engineers' Association held at the Hotel Sherman, Chicago, Ill., addresses were made by R. H. Aishton, president of the American Railway Association; T. C. Powell, president of the Chicago and Eastern Illinois Railroad, and J. E. Taussig, and E. B. Hall, president and superintendent of motive power, respectively, of the Wabash Railway. The committee reports consisted of a consideration of the following subjects: "More and Better Utilization of Locomotives," presented by J. M. Nicholson, chairman; "Recommended Practice in Air Brake Train Handling," presented by J. P. Stewart, chairman; "The Effect of Water Treatment on Locomotive Operation," presented by W. A. Pownall, chairman; "The Value of Back Pressure Gauges and the Limited Cut-Off," presented by A. T. Pfeiffer, chairman. A paper giving a summary of the "Development in Diesel Engines on the Canadian National Railway" was presented by A. N. Boyd, of that company. At one of the sessions a discussion on "Safety," led by Charles E. Hill of the New York Central Lines, was a feature.

In his address, Mr. Aishton touched upon the efficiency record of railways, in the course of which he said: "Despite the high record of efficiency attained by the railroads in 1926, preliminary reports show that for the most part a still higher record was established in the first half of 1927. In the first six months of the year, for instance, the railroads used an average of 2.45 ounces of coal for every ton of freight and equipment hauled one mile, compared with 2.58 ounces in the same period last year. This means that for every pound of coal or its equivalent used, the railroads hauled six and one-half tons of freight and equipment one mile, as compared with six and one-fifth tons of freight and equipment one mile in 1926. This saving in fuel, of course, does not accrue solely to the railroads, for it means an appreciable conservation of our national resources, the elimination of waste and a relief of productive capital into other channels."

On this and the following pages are given abstracts from some of the committee reports.

Effect of Water Treatment on Locomotive Operation

The problem of treatment of water for locomotive use has, during the past ten years, received very valuable and comprehensive study, the results of which are available in reports to this and other railroad organizations. We will therefore endeavor to confine our repot to a discussion of the effect of water treatment on locomotive operation. It is understood that by water treatment is meant treatment for the purpose of preventing formation of scale on the heating surfaces of the boiler and which treatment may be any one of the following methods:

Internal treatment with proprietary boiler compounds, soda, ash or other chemicals applied direct to locomotive boiler or to locomotive tank.

Water softeners using lime, soda ash, sodium aluminate, sulphate of iron, alum.

Soda ash applied to water in roadside storage tank.

Zeolite treatment reducing water to zero hardness before used in boiler.

It is also understood that we are dealing with a situation where the treatment by any of above methods is so directed, supervised and carried out that the purpose of eliminating scale formation in the boilers has been successfully carried out. Partial treatment will, of course, produce advantages in a minor degree, but the results from eliminating scale in the locomotive boiler are so very worthwhile that it is almost self-evident that full treatment of all waters should be the goal as fast as financial conditions permit.

The effect of water treatment on locomotive operation may be divided between the "Advantages" and "Disadvantages." The "Advantages" are given below.

Advantages of Treated Water

The following advantages or good effects of water treatment on locomotive operation are well known to all, and need little explanation, but it may not be amiss to quote figures showing what has been accomplished by use of treated water, and to indicate the possibilities:

Reduction or practical elimination of failures due to leaking boilers.

Reduction in engine failures due to leaky boilers.

Reduce expense of engine failures.

Reduce delays to traffic.

Increased life of flues.

Time and Miles Between Flue Resettings—Best Performances

	Freight		Passenger		Switch	
	Time Mos.	Miles	Time Mos.	Miles	Time Mos.	Miles
Before Treatment	15	45,000	18	90,000	24	45,000
After Treatment	54	200,000	58	350,000	58	150,000

Increased boiler capacity.

Increased boiler efficiency.

Fuel saving.

Water saving.

Reduction in firebox and side sheet renewals.

Firebox renewals per 100 engines per year. Before treatment, 14.1; After treatment, 1.0; Per cent reduction, 93.0.

Reduction in staybolt breakage.

Staybolts broken per engine per year. Untreated division, 54.3; Treated division, 1.2.

Arch flues seldom burned.

Increased time between boiler washings.

Days or Trips Between Boiler Washings or Water Changes

Freight		Passenger		Switch	
Before Treatment	After Treatment	Before Treatment	After Treatment	Before Treatment	After Treatment
5 Days	30 Days	Two round trips	30 days Change water every four round trips	7 Days	30 Days

Time saved and more engines available for service, because of fewer boiler washings, fewer engine failures, and less time in shop and engine house.

Long runs by locomotives made easier.

Reduced pitting of boilers.

General decrease in cost of boiler repairs.

On one road accurate records were kept for a number of years of all direct labor and material charges for all locomotive repairs, and separated between Boiler Repairs and Repairs other than Boiler. On a division using a poor quality of water untreated this percentage of boiler repair to total locomotive repairs was 37%, whereas the best performance of the treated division showed boiler repairs costing only 9% of the total. The difference of 28% is an indication of the maximum possible saving in boiler costs due to water treatment. In actual saving this may mean $1,900 per engine per year based on an average direct labor and material cost from a number of representative roads of $6,800 per engine per year.

The foregoing constitutes a somewhat brief outline of the good effects of water treatment on locomotive operation, but does not attempt to say how to produce these effects other than in the original assumption that the treatment must be such as to eliminate scale formation in the boiler. This *can* be done, and it is the duty of the Water Engineer or Chemist in charge of water treatment to accomplish it. However, while the disadvantage or bad effects of water treatment on locomotive operation may be summed up under the one word "Foaming," your Committee feels that it should attempt to cover very completely the means for preventing this evil.

Disadvantages of Treated Water

1. Foaming, if permitted.
    (a) Waste of fuel and power.
    (b) Decreased amount of superheat.
    (c) Suspended solids carried into superheated units.
2. Waste of fuel and hot water at low blow-off cock.
3. Fuel wasted at washout or water changes. (This will be a saving instead of a loss if washout period is increased.)
4. Limed up branch pipes, injectors and boiler checks.

Foaming, if permitted:—

The words "if permitted" are added after foaming because it is felt that with proper organization and a full understanding of the situation by enginemen and all who have anything to do with handling the treated water, Foaming can and should be avoided in practically all occasions. The above mentioned disadvantages in connection with foaming would then disappear.

All waters have enough dissolved or suspended matter in them so that sooner or later as they become concentrated in the boiler the water will have a tendency to foam. This foaming tendency is usually increased by the addition of any treating chemicals. There is still a division of opinion as to whether foaming in the boiler is caused by the dissolved solids or alkali salts, by the suspended solids or by the dissolved solids in combination with the suspended solids. No attempt will be made to discuss the pros and cons of this matter, but it is pretty definitely known that with any form of treatment which does not remove the hardness before water enters the boiler the foaming tendency of the water can be fairly closely measured by the amount of dissolved solids in the water in the boiler. This is also true to a certain extent with any form of water treatment, although it may be that where the treatment is sufficient to reduce suspended solids in a boiler to a minimum, the concentration of dissolved solids at which the boiler will foam may be somewhat higher. In any event, the foaming results when a concentration occurs in the water in the boiler. To avoid this foaming condition a portion of the concentrated water in the boiler must be removed via the blow-off cock, and replaced with fresh water, in this way reducing the concentration. This exchange of bad for good water through blow-off cock must be done as often as water conditions on the particular operating division demands, and in order to keep below the foaming concentration. This relief of the foaming condition may be accomplished from time to time by means of blow-off cock or may be accomplished by complete change of water at the engine terminal. The concentration at which foaming will occur may also be materially increased through use of anti-foaming compounds, and which may either proportionately reduce the amount of blowing off necessary or make it possible to do without the use of the blow-off cock under certain conditions, providing there is a preference towards frequent changes of water or boiler washings at the engine terminal, rather than using the blow-off cock. The economy of this practice will be discussed later.

The control of the foaming tendency is, therefore, in most instances entirely dependent on the sufficient and timely use of the blow-off cock. Proper application of the blow-off cock will be first considered.

When treated water is used, frequent use of the blow-off cock will be necessary. A type of cock should be selected which is least susceptible to leaking under heavy service, and which will be readily accessible in case repairs are necessary. The shut-off type of blow-off cock, by means of which the hot water from the boiler may be shut off while main blow-off valve is being ground in or repaired, is a type that might prove desirable where conditions are such that even a good blow-off cock entails frequent repairs. Where any form of treatment is used which does not remove the hardness before water enters the boilers, but which so affects the incrusting solids that they do not adhere to the heating surfaces, it becomes desirable to so locate the blow-off cock as to remove the maximum amount of sludge every time the blow-off cock is opened. Critical examination of the deposits in the locomotive boiler shows that scale accumulations are greatest along the belly and in the front throat sheet and the softer material is deposited along the side water legs and in the back water leg, the largest deposit being in the back water leg under the fire door. This condition is brought about through conditions of circulation in the boiler. The circulation is fastest as it approaches the fire box from the boiler check end; it slows up toward the rear of the boiler, and is slowest at the extreme back. The heavier particles of scale are dropped out of circulation toward the front of the boiler, whereas the lighter sludge is carried back toward the rear. Figure 1 illustrates this condition. If this sludge or suspended matter accumulates beyond a certain point it goes back into circulation, is carried around with the water, which is objectionable, not only because it aggravates the foaming tendency of the water, but it will have a tendency to bake on the flues and add to the scale accumulation, even though the water has been treated to the point where it would ordinarily form little or no scale. It will be seen from Figure 1 that the greatest sludge accumulation is on the back mud ring, and it is, therefore, advisable to so locate the blow-off cock that it will remove this back water leg accumulation of sludge. If this accumulation is removed by use of the blow-off cock, the sludge on the sides will

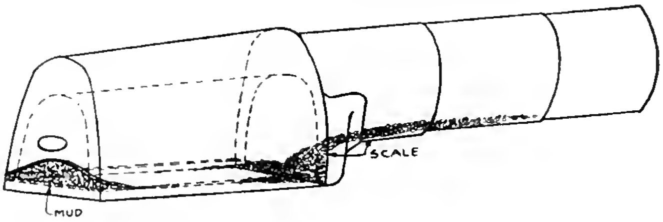


Fig. 1. Mud and Scale Accumulations in Boiler

immediately work back, relieving the condition along the side legs. Figure 2 shows an arrangement consisting of blow-off cock in the left back corner and connected to a perforated pipe, which lies on the back mud ring. It is important not to have too many perforations in this pipe, otherwise the sludge will only be removed from part of the back water leg instead of cleaning out the entire space. This method of blowing off locomotive boilers is considered almost a necessity in connection with any form of treatment which does not remove the scale forming material before it enters the boilers.

Where all water used by the boiler has been passed through water softeners of Zeolite plants, and its hardness reduced to a low figure, there is a relatively small amount of sludge deposited in the boiler, and not much blowing off is necessary from the standpoint of removing sludge accumulation. However, it is felt advisable even with a small amount of sludge to locate the blow-off cock and the perforated pipe as described above. Although the back water leg blow-off cock described above is considered the most desirable means of reducing concentration, and at the same time removing sludge, it is recognized that blow-off cock located near front throat sheet, and drawing through system of perforated pipe from front mud ring and along belly of the boiler may have considerable merit in removing mixtures of mud and scale which are deposited in these places where the water treatment has not been such as to completely prevent scale formation.

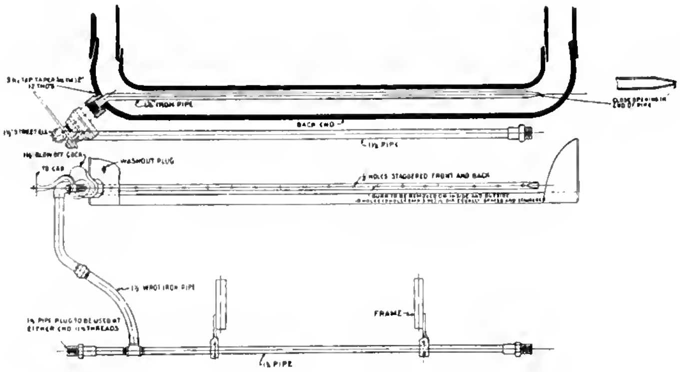


Fig. 2. Back Water Leg Blow-Off Cock With Perforated Pipe

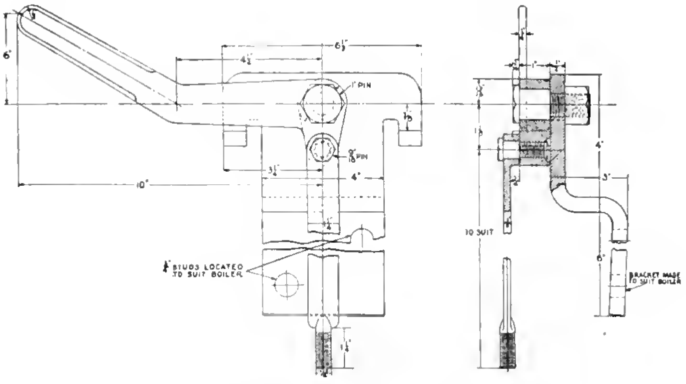


Fig. 3. Cocks and Valves—Blow-Off Cock Operating Rigging

There is a question as to whether right or left side of the boiler is preferable for the blow-off cock location. The Committee feels that it should be located on the left back corner and operated by the fireman. There are usually less appliances obstructing the application of the blow-off cock on the left side than on the right.

Some types of blow-off cocks have to be held open by the engineman, and at times it becomes desirable that blow-off cocks be held open from two to three minutes at a time. Figures 3 and 4 show an arrangement by which the blow-off cock can be opened with slight effort, and held open until lever is returned to its original position by the engineman.

Some railroads using treated water are making use of a blow-off arrangement wherein a small amount of water may be discharged continuously for as long a period as desired, while engine is in motion. This usually consists of any standard blow-off cock fitted with a bushing with hole ¼" in diameter, and which will ordinarily discharge about 600 gallons of water per hour, or the equivalent of a full gauge of water. The discharge from the blow-off cock is piped into a muffler and the discharged water drops on to the track without any noise or without spattering equipment. This appliance is used, as a rule, only on passenger engines, and which provides engineer with excellent means of easily relieving any foaming tendency which may develop en route. Instead of using standard blow-off cock a ¾" angle globe valve may be used with a ¼" blow-off using a standard blow-off cock, and located near mud ring at a point where it removes sludge in addition to removing the concentrated water. The removal of the sludge is desirable but not considered necessary, and there is occasional trouble experienced with the application at mud ring, by reason of the ¼" hole becoming stopped up by pieces of scale. Another recommended application which has met with success is ¾" angle valve located on the back head within easy reach of the engineer, and as shown on Figure 6.

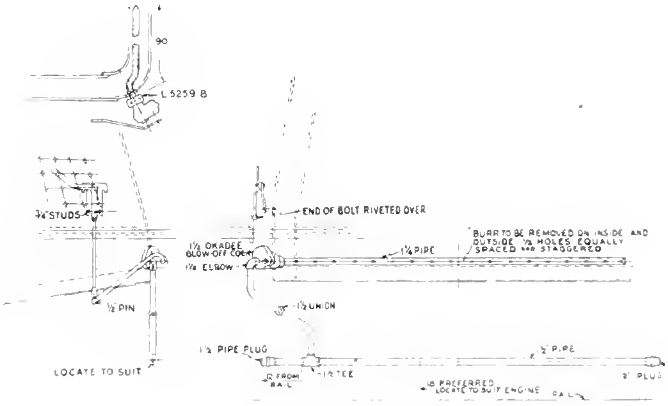


Fig. 4. Blow-Off Cock Arrangement

Blowing Off at Terminals

Most roads using treated water make a practice of blowing off engines on arrival at the cinder pit. Some arrangements are necessary, particularly in congested districts, to confine the steam and water blown off.

Wherever space permits it is easier to use some type of blow-off box, as this does not entail the labor of connecting pipe from the blow-off cock to some system and underground piping.

If space conditions do not permit installation of the blow-off box it is necessary to have a system of underground piping by means of which water can be blown out of an engine and through this pipe into some catch basin or other convenient place. It is necessary to provide flexible connections and proper piping from the blow-off cock to enable connecting the blow-off cock to the underground piping.

There are some conditions, such as switch engines in crowded terminals or road engines running in densely populated districts, where it is difficult to find opportunity to blow off engine without whitening adjacent property or equipment. This difficulty is overcome by use of muffler applied to end of the blow-off pipe. Mufflers are also used in connection with ¼" blow-off cock as described above. Where the main blow-off cock is used through one of these mufflers the hot water will be discharged down between the rails, and there will be more or less steam surrounding the engine, if engine is standing still, but if engine is moving this steam is dissipated and is not objectionable. If it is the practice to blow off engines into hot water washout system at the engine terminals, it is necessary where muffler is used to provide a by-pass pipe with necessary valves so that muffler can be shut off. Cut of a commercial blow-off muffler is shown. Figure 7 shows a blow-off muffler used in connection with ¼" blow-off.

Organization and Instruction Relative to Locomotive Operation Under Treated Water Conditions

It is felt that one of the most important features in connection with the use of treated water is the campaign of education, and particularly preliminary to starting the use of treated water among enginemen and all others that are in any way concerned with the operation of trains and locomotives. It has been not uncommon experience to have water treatment get in very bad repute and even to be abandoned on account of the delays on the road caused by foaming engines at the time treatment was started, and which trouble could have been avoided if the enginemen had been sufficiently educated in advance as to how to successfully handle the situation. Water treatment is not a complicated proposition, and instead of making a mystery of it every effort should be made to familiarize employees with the methods of treatment and of handling the treated water and the results, both good and bad, which are incidental to its use. Considerable of this report has been devoted to the blow-off cock, its application and means of blowing off at terminals, etc. Before treatment is started on any engine operating district all engines should be equipped with suitable blow-off cock, so applied that they can be operated conveniently, and so that engines can be blown off whenever necessary. The engine terminals should also have blow-off boxes or underground piping arrangements, in order to properly take care of the terminal blowing off as engines arrive at or leave engine terminal. The blowing off which engines receive at the terminal relieves the enginemen from a certain amount of road blowing for freight engines, and usually in case of passenger engines it takes care of all the blow-off necessary. It is thought advisable to even start the blowing off practice just before treatment is started, and in this way avoid some loss of time due to foaming.

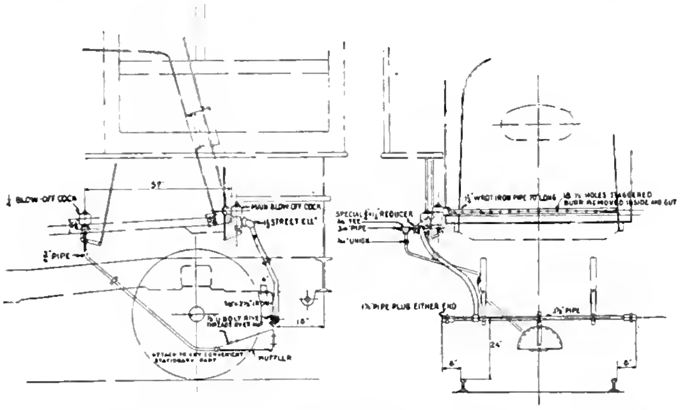


Fig. 5. Blow-Off Cocks and Piping Arrangement for Passenger Engines

The preliminary education campaign should start first with the Road Foreman and Master Mechanics, and the Road Foreman should then transmit information relative to treated water and how to handle it should be sent out to all enginemen and acknowledgment obtained of the letter, and the matter should then be discussed in meetings before treatment is started. After treatment has been in effect there will always be plenty of discussion at meetings attended by the enginemen. Fuel meetings have proven to be an excellent occasion for discussing water treatment.

The amount of blowing off necessary to control foaming varies considerably with the quality of the untreated water, and the amount of treatment added, and it is difficult to formulate any definite set of instructions. The Committee realizes that in some districts the water conditions and the treatment are such that engines may be handled successfully with very little use of the blow-off cock, but our investigations indicated on a railroad where waters over a division are treated, successful handling of the situation depends entirely on the proper use of the blow-off cock. Examples of letters of instructions to enginemen relative to blowing off are given herewith for different railroads.

Treated Water—To Enginemen

Waters containing sulphate of lime cause hard scale to be formed in boilers, and, to prevent this scale, such waters are treated with the necessary amount of soda ash.

The bad effect of soda ash is, as you all know, the increase in foaming tendency of the water. The soda ash or the sulphate of soda (the result of its action on the lime) remains dissolved in the water in the boiler, increasing in amount as more water is evaporated, and when enough has accumulated in the boiler, water is thrown over with the steam and foaming occurs.

The only way you can avoid this condition is to remove part of the soda ash by blowing the water out and replacing it with fresh water from the tank, and you must blow out a sufficient quantity of water to bring about this result.

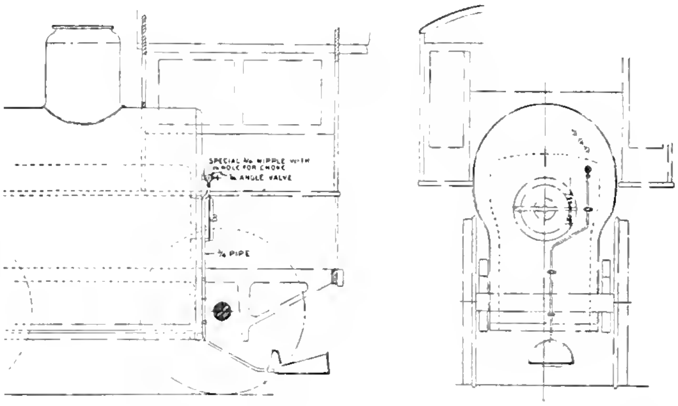


Fig. 6. Blow-Off Cock on Back Head of Narrow Fire-Box Engines

Some waters are more foamy than others, and a large amount of water must be blown off after taking these waters.

Do not blow off while or after having had injector on and not working steam, for the cold fresh water falls to bottom and will be taken out instead of the bad water.

Do not neglect your blowing because you have a light train or because engine has just been washed. You may leave boiler in bad shape for the next man, who may have a heavy train.

Blow out at water tanks if you can do so without damaging adjoining property; you can then leave with full tank of water and will not have to waste water between water stops.

Do not carry water high in glass. Work engine gradually in pulling out of town, so as to avoid drawing water over.

The blow-off cock is the only way to stop engine from foaming, and blowing off will *always* do this if enough is done.

The object of water treatment is to reduce leaking trouble and to prolong life of flues and fire-boxes. The success of the treatment depends first on always having the proper amount of treatment for the water, and secondly on having enough timely blowing off done to keep the boiler from foaming. We earnestly solicit your cooperation in making the treatment successful.

Signed:—Genl. Road Foreman of Engines.

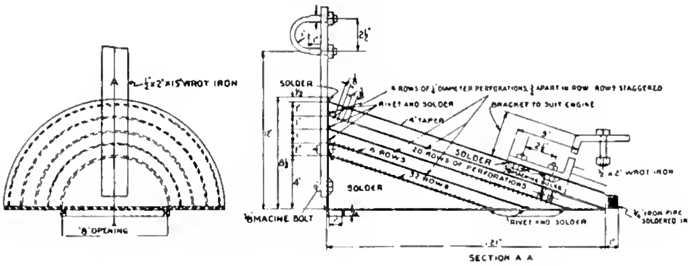


Fig. 7. Muffler for Quarter-Inch Blow-Off Cock

Instructions for Blowing Down Water in Boilers Equipped With Standard Mud-Ring Blow-Off Cock

Instructions for Shop Forces:—

1. Engines being dispatched must have water blown down from a full glass to one gauge, or, to one inch in the glass, as short a time as consistent before dispatchment, and will have water blown down from a full glass to one gauge, or, one inch in the glass, upon arrival at terminal by opening the blow-off cock wide open with not less than 80% of full boiler steam pressure.

2. Boilers reported foaming on arrival at terminal will have water blown down from a full glass to one gauge, or, one inch in glass (twice), both on arrival and before dispatchment, or water will be changed in boiler. During time boiler is being blown down, injector will NOT be operated.

3. The shop supervision which dispatches the engines will be held responsible for the foaming of boilers:

In passenger engines which foam in the first 75 miles out of terminal.

In freight engines which foam in the first 50 miles out of terminal.

In yard engines which foam in the first 6 hours out of terminal.

Instructions to Enginemen:—

Engines in Passenger Service

4. Where conditions will permit, blow-off cock will be opened wide for a period of 15 seconds every 15 miles.

Engines in Freight Service

5. Where conditions will permit, blow-off cock will be opened wide for a period of 15 seconds every seven miles.

Engines in Yard Service

6. Where conditions will permit, blow-off cock will be opened wide for a period of 15 seconds every hour.

7. Where conditions will permit, all road engines will have blow-off cock opened wide for a period of 15 seconds just before or just after engine has started the train, upon leaving stations or sidings.

8. If these instructions do not prevent foaming, Engineer will ease off on throttle (using blow-off cock wide open) and, if necessary, come to a stop and fill boiler to full glass and blow down to one gauge or one inch in the glass.

9. Enginemen must not use blow-off cock passing through interlocking plants.

10. Enginemen will be held responsible for boilers foaming, except as specified above as to the responsibility of the shop supervision for foaming after leaving terminal.

To All Enginemen

Effective at once we will start using flash system of blowing out boilers. You will blow out boilers for a period of 10 seconds, at least once each hour.

Use blow-off cock on side of engine away from wind.

A blow-off cock open 10 seconds does just as much good as if it were open 5 minutes.

Signed: Traveling Engineer.

It will be noted that the three foregoing sets of instructions represent first, rather heavy use of the blow-off cock; second, moderate use of blow-off cock, and third, the flash system, whereby a relatively small amount of water is wasted by blowing off. Undoubtedly each method was exactly what was necessary to control foaming on the road concerned, the greater use of blow-off cock resulting from heavier treatment or higher natural foaming tendency of the raw water, and the light blowing off being sufficient to take care of lightly treated water.

Enginemen when first coming in contact with the treated water situation, even though they have had considerable advance information as to how to handle the situation, will frequently find themselves with a foaming boiler and sincerely believe that they have done all possible to prevent the foaming and that the situation is beyond their control. The best way to handle cases of this sort is to have dispatchers instructed when report comes in that engine is foaming and cannot handle the train, to have train take siding, and road foreman will be sent out to show the engineman how to put his water in a non-foaming condition and handle train successfully to terminal. A few cases handled in this manner have a very beneficial effect, as they are discussed freely among enginemen, and the foaming trouble soon becomes a thing of the past.

Whenever the blow-off cock is open a certain amount of heat is wasted to the atmosphere, and it is thought by many that this waste of fuel and water is excessive and even prohibitive. There is no question but what this is a waste, but the amount of fuel and water wasted in this manner can be definitely measured and which constitutes an important part of the cost of treating water. The fuel wasted under average conditions may be 1½ to 2% of the total fuel used. Although the cost of this fuel wasted is considerable, it is far outweighed by the many financial benefits derived through the use of treated water. Moreover under average conditions it will be found that this fuel waste constitutes less than it would cost to change the water or wash the boiler in the enginehouse at fairly frequent intervals.

This is shown as one of the disadvantages of treated water in event proper use of the blow-off cock is not made and frequent water changes and washouts are resorted to. Under average water conditions it is possible to very materially increase the mileage between boiler washing or water change. The cost of blowing off is less than water change or boilerwash, so that there is really a saving instead of a loss under this heading.

This is not a common trouble incidental to the use of treated water, and probably should not be included as one of the disadvantages. It is a trouble, however, that sometimes occurs, and can possibly be traced in some cases to improper water treatment.

The major part of the Committee's report has been devoted to blow-off cocks and blowing off, as it is felt that the control of the foaming situation represents the most important part of the "Effect of Water Treatment on Locomotive Operation." We do not feel that railroads having water treatment are taking full advantage of the situation as regards reduced boiler washing. We appreciate that opinion is divided on this subject, in fact the majority seem to lean toward frequent water changes and boiler washings rather than extensive use of the blow-off cock. Experience shows plainly that if the enginemen are educated to the proper use of the blow-off cock to prevent foaming, there will be very few delays on account of foaming engines, whereas if they always rely on the boilers being washed or water changed they will often get into trouble with foaming engines and not know how to take care of the situation. We are mindful of the fact that there are extreme conditions where blowing off will not control foaming, where it is necessary to use anti-foaming compound in combination with the blow-off cock, and where even the frequent washouts or water changes are necessary in order to successfully operate an engine from one terminal to another. This is a matter, of course, which must be decided for each individual engine operating district, and even under these conditions it is possible to operate the engine without foaming trouble. In addition to insisting on proper education and supervision of enginemen in the matter of operating engines under treated water conditions, we want to also emphasize and urge proper supervision of water treatment with a competent organization to handle it.

The committee consisted of W. A. Pownall, Chairman, Harry B. Kelly, J. W. Wells, W. L. Robinson, and P. E. Keenan.

Value of Back Pressure Gauges and Limited Cut-Off

With a view to developing information upon this subject, questionnaires were sent to the mechanical officials of several railroads and this report is a résumé of the information so collected. Part 1 deals with the value of back pressure gauge and Part 2 to the value of limited cut-off.

Part 1—Value of Back Pressure Gauges

Replies were received from 20 railroads. Of this number, two reported that they used such gauges, but did not have sufficient information available to warrant a reply as to definite results; two reported that they did not have such a device in service. No complete information was received as to the total number of such devices in service. Of the the 18 railroads reporting the use of back pressure gauges; thirteen reported using the Ashcroft Duplex type, one hand registering steam chest pressure and the other registering back pressure; two roads reported using the single type registering only the back pressure; and three roads reported using the Ashton double hand gauge.

Two roads reported piping the back pressure side of a duplex gauge into back and front exhaust cavities of cylinder, but did not mention location of piping for steam chest pressure. One road reported piping the back pressure side of the gauge into the exhaust cavity and the steam chest pressure side into the right valve chamber. The two roads using the single gauge for registering back pressure only piped the gauge to each of the exhaust cavities in the valve chamber with globe valves in the line to enable a comparison to be made between the two cylinders. Nine railroads using the duplex type of gauge reported piping the back pressure side of the gauge to each of the four exhaust cavities of the valve chambers and to each of the two steam pipes, with globe valves enabling the two cylinders of the engine to be compared. One railroad reported piping the back pressure side of the gauge to the two exhaust cavities of the right cylinder and the steam chest pressure side to the right steam pipe immediately above the valve chamber. It might be interesting to note in this connection that one railroad recommended the use of the dust collector immediately behind the cylinder saddle, this to be made of ¾-inch pipe, the claim being made that the cleaning of this dirt collector from time to time would prevent the clogging of the pipes under the jacket.

The prevention of the fluctuation of the back pressure hand on the gauge when the engine is working seems to have been one of the major difficulties in the use of the gauge. Nine roads reported that this hand did not fluctuate and was prevented by one or more of the following means: by the use of a heavy hand and compensating spring, by the use of a pulsating valve, by the use of a coil in the pipe line filled with oil, and by the use of a uniflow fitting, a description of which was not given.

Four roads reported that the hand did fluctuate but that such fluctuation was considerably reduced by the following means: by the use of a triple circular pipe bend at the gauge, by the use of a pulsating valve, by the use of a choke, and by increasing the number of coils in the syphons.

One road reported that the back pressure hand fluctuated only when starting the train and that this could be overcome by choking the gauge at low speeds. One road reported that the hand fluctuated only when the train was drifting and that this condition was considerably ameliorated by using the proper cut-off and by judicious use of the drifting valve or drifting throttle.

There was considerable difference of opinion on this matter and it is a rather difficult matter for your committee to set a value that would represent a composite opinion. We are listing below in detail the replies relative to this question:

R. R.	*Passenger*		*Freight*	
	Maximum	Minimum	Maximum	Minimum
1.	5 lbs.	3 lbs.		
2.	6 lbs.	3 lbs.	10 lbs.	4 lbs.
3.	12 lbs.	4 lbs.	14 lbs.	6 lbs.
4.	7 lbs.	5 lbs.	7 lbs.	5 lbs.
5.	6 lbs.	3 lbs.	8 lbs.	4 lbs.
6.	7 lbs.	5 lbs.	12 lbs.	7 lbs.
7.	6 lbs.	Least to do work	10 lbs.	Least to do work
8.	10 lbs.	4 lbs.	14 lbs.	6 lbs.
9.	Least consistent with making time		Least consistent with making time	
10.	14 lbs.	8 lbs.	12 lbs.	8 lbs.
11.	None in service		10 lbs.	8 ibs.
			5 lbs.	Mallets
			5 lbs.	3 ibs.
				Mikados
12.	8 lbs.	6 lbs.	12 lbs.	10 lbs.
13.	Back pressure a function of drawbar horsepower.			
14.	Left to judgment of engineer.			

Value of Back Pressure Gauge in Determining Incorrect Nozzle and Valve Setting

All fourteen railroads listed next above reported that the back pressure gauge was of material assistance in determining incorrect exhaust nozzle sizes. Several roads reported that this was accomplished by a comparison of the back pressures produced by locomotives of the same class, while other roads advised that excessive back pressure coupled with a slowing up of the locomotive at proper cut-off would indicate incorrect exhaust nozzle.

Thirteen of the fourteen roads above listed advised that the back pressure gauge was of value in correcting irregularities in valve setting. As a matter of information the replies of the roads are given below:

R. R. *How Irregularities are Determined*

1. By pulsation of gauge hands at low speed.
2. Not given.
3. By fluctuation of gauge hands.
4. By excessive fluctuation of gauge hands and by excessive back pressure.
5. If engine is very lame, back pressure will fluctuate.
6. By being unable to maintain predetermined steam pressure or reduce back pressure.
7. By irregularities in back pressure on the two sides of the engine.
8. By irregularities in valve setting increases back pressure.
9. Unable to say, no experiments have been made.
10. By pulsation of back pressure for irregular exhausts.
11. By irregularities in back pressure on the two sides of the engine. In Mallets by fluctuations in receiver pressure when reverse lever is changed.
12. If unable to make time when correct back pressure is maintained.
13. By discrepancies in back pressure at corresponding positions of the piston.
14. At slow speed, gauge indicates varying back pressure at same position of stroke.

On the question of the value of back pressure gauge when drifting, twelve roads reported that it was of value in indicating the presence of vacuum in the cylinders and was thus instrumental in preventing the scoring of cylinders through the presence of dirt in them and in preventing the destruction of lubrication by the presence of exhaust gases. Two roads reported that they had found the back pressure gauge of no particular value when drifting.

Nine of the fourteen roads reported the back pressure gauge of value in determining if a reverse gear is creeping. Two reported that it was of no value in this respect and three roads did not reply.

One of the questions arising in connection with the use of back pressure gauges is whether, when the engine slips, water is siphoned from the coil in the pipe line to the gauge with probable consequent damage to the gauge. Of the fourteen roads replying to the questionnaire, eight reported having no trouble in this respect: one road reported no trouble except when drifting; one road reported no trouble if gauge was fitted with uniflow fitting: one road reported trouble unless gauge was properly piped: and three roads did not reply to this question.

Accuracy and Durability of Back Pressure Gauges

In order to understand more clearly the experiences of the various railroads with respect to the accuracy and durability of back pressure gauges it might be well to quote the wording of this question as included in the questionnaire: "For what length of time will the gauge hold true indication?" A summary of the replies is given below:

R. R. *Reply*

1. On passenger engines nearly two years. On freight engines not so long.
2. Varies with service.
3. About five months.
4. Seldom exceed 30 days.
5. From 6 to 12 months.
6. If pulsating valve is properly adjusted will last as long as boiler pressure gauge.
7. No trouble experienced.
8. Ashcroft gauge—5 months. Ashton in service 4 months still accurate.
9. Tested and inspected same as boiler pressure gauge.
10. Very short time due to failure of Bourdon tube.
11. Unable to give definite reply.

The question covering this phase of the subject was worded as follows: "Can the back pressure be held at one particular point by engineman and, regardless of train, weather, or speed, will he be able to always make running time to advantage?" The replies to this question are listed below:

R. R. *Reply*

1. Yes, but under adverse weather conditions could not be made.
2. No reply.
3. No, varies with different speeds and cut-offs where grades are not uniform.
4. No. Back pressure increases when climbing grades.
5. No. This matter is left to judgment of the engineman.
6. No reply.
7. No reply.
8. No reply.
9. No.
10. Yes.
11. No. It varies with speed, position of throttle, position of reverse lever, and boiler pressure.
12. Freight service, yes.
    Passenger service, no. Schedule time is ruling factor.
13. Yes.
14. No.

Results Anticipated from the Use of Back Pressure Gauges

The addition of any device to a locomotive can be justified only on the basis of the results it expects to accomplish in better locomotive operation. With this in view a number of railroads were asked what results they expected to realize through the use of back pressure gauges. The following table summarizes the replies from several roads.

R. R.

1. Enables enginemen to work engine to advantage. Saves fuel. Prevents abuses of engine.
2. Better handling of trains. Heavier trains in freight service. Economy of fuel and water.
3. Proper handling of engine. Economy of fuel and water.
4. More economical operation. Gauge indicates correct cut-off for each particular speed.
5. Gives Road Foreman better opportunity to demonstrate to enginemen how to handle engine to obtain best results.

6. No reply.
7. No reply.
8. No reply.
9. Economy of fuel due to more efficient operation of engine. Reduction in wear of valve bushings, valve and piston rings, pistons, cylinder bushings due to more intelligent drifting.
10. Economy of fuel.
11. Indicates proper throttle opening, whether superheater had sufficient capacity, if valves and cylinders packing are blowing, correct or incorrect nozzle, proper or improper operation of engine.
12. Passenger service. Make better time with less abuse of engine. Freight service. Heavier trains at increased speed.
13. Economy of fuel
14. Economy of fuel and better maintenance of schedules.

Results of Tests

Below is observation made of various operating factors over a division on a large Eastern road with and without the use of a duplex cut-off control gauge:

Item	*Without Gauge Being Used*	*With Gauge Being Used*
Type of service	*Freight*	*Freight*
Miles run	48	48
Actual tons in train	2180	2326
Temperature	60	55
Gross ton miles	104,640	111.648
Average speed	18.46 MPH	22.86 MPH
Total time on road	3 Hr., 15 in.	2 Hr., 19 Min.
Running time	2 Hr., 26 Min.	2 Hr., 06 Min.
Coal consumed	9600 Lbs.	7800 Lbs.
Water consumed	63,700 Lbs.	53,613 Lbs.
Coal per 1000 gross ton mile..	91.7 Lbs.	69.9 Lbs.
Average boiler pressure	193.3 Lbs.	197.0 Lbs.
Average cut-off	41.6%	31.0%
Average throttle opening	68.0%	88.0%

It must be borne in mind that this was not a dynamometer test and no accurate measure of train resistance was obtained. The theoretical train resistance over the ruling grade at 10 miles per hour in the case of the two trains, being 27,032 lbs. in the train without the use of the gauge and 27,167 lbs. in the train with the use of the gauge.

Limited Cut-Off

The development of the limited cut-off locomotive in heavy freight service was brought about in an endeavor to improve the expansive use of steam. In certain phases of freight train operation the prevailing practice is to load the engine so as to require operation at late cut-offs for relatively long periods of time, by proportioning cylinder diameters for a 50%, 60%, or 70% cut-off as maximum, a more expansive use of steam can be obtained.

The use of limited cut-off entails no radical changes in the design of the locomotive. The principal change is the cutting of two slots known as auxiliary ports in the valve bushings. The use of limited cut-off results in economy of fuel and water with small sacrifice of starting effort and acceleration. In expansion ratio the limited cut-off locomotive approaches the compound engine in uniformity of torque it is almost as good as the three cylinder engine and with this it combines the simplicity of the ordinary two cylinder engine, maintenance costs should be no greater.

In nearly all cases of securing the advantages of a new mechanism we must sacrifice some of the features of the old, in the case of a limited cut-off engine the piston pressure must be increased which in turn means an increase in the weight of reciprocating parts. When the limited cut-off engine stops in such a position as to require all the steam for starting to pass through one of the auxiliary ports, time will be required to build up a steam chest pressure equal to boiler pressure, an occurrence of this kind takes place so seldom that it does not need to be given serious consideration.

The design features which differ from the ordinary locomotive, but which with very small differences in weight and cost, are an increase steam lap on the valve, a small auxiliary port cut through the valve bushing at each end of the steam chest, and a change in the ratio of the combination lever to compensate for the increased steam lap.

One of the large eastern roads, a pioneer in the development of the limited cut-off, found that the increased weight of the reciprocating parts amounted to about 1⅛% of the total weight of a heavy Mikado locomotive, this increase in weight should not be a serious drawback in average heavy freight service. The limited cut-off can be used on a locomotive without increasing its total weight. In order to do this, some part of the locomotive must be reduced in weight 1⅛% if the piston pressure is not increased and 2¼% if the piston pressure is increased. Due to the economy of the limited cut-off a 10% reduction in heating surface should be sufficient to compensate for this.

From actual tests made by the road above noted it was found that the water saving of the limited cut-off over the ordinary locomotive was from 11% to 38% depending upon the load and speed. Naturally this saving would be greater for the slow speeds than for the higher speeds.

From this it is to believe that we can safely infer that the limited cut-off locomotive should produce a coal and water saving in heavy slow freight service of about 20% and in fast freight service some 10% or 15%. In passenger service we do not believe there is a place for the limited cut-off because the negative effect due to increased weight of reciprocating parts of 10%, or less.

Your committee received only a small amount of information covering the use of limited cut-off. Of the 20 railroads replying to our questionnaire, only four reported as having had experience with the limited cut-off. None of the roads reported the use of the limited cut-off in passenger service.

Each of the roads reported a different percentage figure relative to maximum cut-off. Three roads each reported 60%, 70% and 80% respectively, the fourth road apparently misunderstood our questionnaire, reported 25%.

All four roads reported the results obtained from the use of limited cut-off more satisfactory than those obtained from the use of a full stroke cut-off.

One road reports no noticeable difference in starting trains, while three roads reported that the limited cut-off was at a slight disadvantage in starting, but handled the train more satisfactorily than full stroke cut-off once the train was under way.

All four roads reported that their experience with the limited cut-off reflected economies in fuel and water over the locomotive not so equipped.

Three roads reported no special difficulty in valve setting on a locomotive equipped with limited cut-off while one road advised that it was slightly more difficult to set valves on an engine of this type.

One road reported an increase in the weight of reciprocating parts due to use of limited cut-off. One road reported a decrease in such weights, and two roads advised that no changes in these weights were made. None of the roads reported any appreciable increase in wear and tear of the reciprocating parts due to the use of the limited cut-off.

The Committee consisted of A. T. Pfeiffer, Chairman,

J. F. Buckley, T. B. Burgess, Harry Clewer and W. B. Kilgore.

Largest Storage Battery Locomotive

The largest storage battery locomotive in the world, weighing 110 tons and capable of hauling a 1,500-ton train, has just been purchased by the State Line Generating Company for service in its yard at Hammond, Ind.

This locomotive, built by the General Electric and Electric Storage Battery Companies, has all the advantages of an electric locomotive, but does not require an overhead trolley or third rail for its power. It is noiseless and smokeless in operation, and can accelerate quicker and move a heavy load much faster than other types of switching locomotives.

Its huge storage battery, weighing 39 tons, the largest ever manufactured for this purpose, will deliver 1,000 horsepower to the driving motors.

A motor-generator set installed in the cab will permit the charging of the battery from a 2,300-volt circuit in the company's plant.

Great Northern Railway Obtains Largest Motor-Generator Type Electric Locomotive

The largest motor-generator type electric locomotive in the world, one of four being built by the General Electric Company for the Great Northern Railway for hauling passenger and freight trains through the new 7¾-mile tunnel piercing the Cascade Mountains, is being exhibited at cities along the Great Northern road. It is remaining at different places for a day at a time, and invitations have been sent out generally to railway engineers and executives to inspect the new "King of the Rails."

Not only have these locomotives greater weight on driving wheels than any single-cab units ever before built, but they also are designed for higher operating speeds than is usual in freight service. They are, therefore, particularly adapted to handling the Oriental Limited and other passenger trains through the electric zone over the Cascades.

The locomotive has been so designed that speeds up to 50 miles an hour may be attained without interfering with good riding qualities.

This new locomotive utilizes the advantages of both alternating and direct current. Within its cab is a traveling substation, taking 11,000-volt alternating current from the overhead trolley wire and changing it to low-voltage direct current for operating the driving motors.

In this locomotive the transforming equipment is completely automatic and can be started or stopped almost instantly by pressing a button in the engineer's compartment. Two of these locomotives, operating together as a single unit, will be used on heavy freight trains. This double unit will have a nominal rating of 5000 kw. or 6,600 horsepower. Because of the great flexibility and wide speed range of its regenerative electric braking, this type of electric unit is particularly suited to handling trains over heavy grades such as are encountered by the Great Northern in crossing the Cascade Range. The speed of the trains down the grade can be controlled with a minimum of switching and held at any desired rate, at the same time transforming the "gravitational" energy of the train into electric power and sending it back over the trolley wire for use at stations or by other trains.

Each of the new electric units contains a 2500-kilowatt synchronous motor-generator set which supplies direct-current power to the motors mounted on each of the six driving axles.

The Great Northern Railway was the first transcontinental system to use electric locomotives, this pioneer equipment being initially operated in 1909. At that time the electrically-operated track through the Cascade tunnel was about four miles in length. Four electric locomotives, weighing 115 tons each, were used for more than 17 years. Regenerative electric braking was used on these locomotives, this being the first commercial application of this feature in this country. The use of electric power in this tunnel successfully relieved smoke conditions and thus expedited the handling of both passenger and freight traffic.

Coincident with the building of the new tunnel between Berne and Scenic, which will be the longest on the American continent, an extensive program of grade and curve reduction and the elimination of snow sheds between Wenatchee on the east slope of the Cascades and Skykomish on the west has been started. The Great Northern is building a change of line from Peshastin to Winton. The new line will run through an open country, thus eliminating the necessity for snow sheds and reducing winter operating costs. The electrification, now 27 miles of single track, will be extended to make an electrified zone 96 miles in length. This will make possible a material reduction in the running time of freight trains.

Electrical operation of the famous Oriental Limited and other passenger trains, now through the present Cascade tunnel and later through the new 7¾ miles tunnel, will give additional comfort and safety to travelers over the Great Northern lines.

The principal weights and dimensions of the new locomotive unit are:

Total weight	518,000 lbs.
Weight on drivers	409,800 lbs.
Length over couplers	73 ft. 9 in.
Length of wheel base	58 ft. 8 in.
Number of driving axles	6
Number of guiding axles	2
Diameter of driving wheels	55 in.
Diameter of guiding wheels	36 in.
Number of motors	6
Speed continuous rating	18.7 m.p.h.
Maximum speed	50 m.p.h.

The present electric zone of the Great Northern Railway extends westward from the east portal of the old tunnel to Skykomish, at the foot of a 2.2 per cent grade. Extensions are planned to Wenatchee on the east and Goldbar on the west.

Power for the Great Northern electric zone is supplied by Puget Sound Power and Light Company from its various waterpower plants, and also from the hydro-electric station built by the railway company at Tumwater.

Locomotive Condition Best Ever Recorded

Fewer locomotives were in need of repair on Class 1 railroads of the United States on September 1 than at any time since the preparation of these statistics began in 1920, the Car Service Division of the American Railway Association announces. The total number of locomotives in need of repair was 8,502 or 13.9 per cent of the number on line. This was a decrease of 33 locomotives under the best previous record, established on August 1, this year, at which time there were 8,535 or fourteen per cent.

The number of locomotives in need of repair on September 1 was a decrease of 572 compared with the number of such locomotives on August 15, at which time there were 9,074 or 14.9 per cent.

Grinder Performance on Heavy Railway Jobs

Proves Applicable to Variety of Work at a Large Eastern Railway Shop

A heavy-duty face grinder supplied by the Diamond Machine Company has been used to advantage in various kinds of facing work in the shops of a large eastern railroad since 1924, according to a survey recently completed by the A. C. Nielsen Company, Engineers, Chicago. It is employed primarily for locomotive parts, but is also used on a variety of other work.

Work now done on the grinder was formerly handled on boring mills and horizontal milling machines and on another grinder of an older model. The new Diamond machine has shown many advantages over the machines which it supplants.

The grinder has been applied successfully to the facing of exhaust boxes, stoker engine plates, guide bars and steam pipes for Pacific, Mikado, Santa Fe and Consolidation locomotives.

Work on other types of equipment includes the facing of die blocks used in the forge shop and the grinding of shear blades used in the steel plate department.

Table A, below, lists these jobs in detail, showing the material of which they are made, the surfaces finished, the amount of material removed and the average grinding time. It should be noted that grinding time is determined on the basis of work turned out in an average day. The actual grinding time may be less than that here shown.

Guide bars form the bulk of the work now handled, these being of a steel whose manganese content ranges from .4 to .7 per cent.

Work to be done on the grinder is clamped to a horizontal table with longitudinal travel. A 40-hp. motor drives the table and the 30-inch grinding wheel and supplies power to a small pump used to circulate a 25 per cent borax grinding solution.

The grinding wheel is of the 12-segment type, Norton grade "O" material in grain size No. 16. The wheel is ordinarily good for 80 to 120 hours of heavy grinding before complete replacement is required.

Operating Methods and Schedules

The grinder is in regular service for one 8-hour shift each day. One man is in complete charge of all operations, using a ½-ton air hoist in putting work on and taking it from the table. No special skill is required to operate the machine. The present operator was a mechanic's helper originally but learned to run the Diamond grinder satisfactorily in a very short time.

TABLE A

Description of Part	Material	Portion Ground	Approximate Material Removed	*Average Time
Exhaust box (outside dia. of flange is 13")	Grey iron	Steam joint connecting with cylinder	⅛"	½ hr. on new piece—¼ hr. for touching up old part
Stoker engine plate (about 14"x16" face)	Grey iron	One face	1/32"	1 to 1½ hr.
Steam pipes (6 and 7" sizes)	Grey iron	Face joint	¼"-¾"	1⅓ hr. on a 7" pipe
Guides (typical guide 3⅛" x 6-63/64" x 3¾")	Open hearth steel forgings	Face 3 sides	1/16"-3/32"	1 hour
Die blocks for forge shop (Face approximately 8"x10")	Soft steel annealed	Grind face on each block	1/32"-3/32"	1 hour per pair
Shear blades for punch press type shears (for 60" shears)	Carbon steel	Cutting edges	1/16"-⅛"	⅔ hour per pair

*Based on average working conditions, including all lost time.

Repairs have been remarkably low in spite of the hard service to which the grinder is being subjected. Except for renewals of the grinding wheel, the only part replaced since the machine was installed is one small fibre gear.

TABLE B

Annual Fixed Charges		
Depreciation (cost plus installation) $8,500.00 × 10%		$ 850.00
*Average interest at 6%—11/10 × $8,500.00 × .06/2		280.50
Annual allowance for repairs, estimated at 3%—(only repair cost to date has been the replacement of one fibre gear)		255.00
Total annual fixed charge		$1,385.50
Daily Operating Cost		
Daily fixed cost—$1,385.50 ÷ 275 days		$ 5.04
Average daily cost of grinding wheel—$51.84 ÷ (12 days × 8 hr.)		4.32
Borax grinding solution—¼ lb. per day @ $0.0709 per lb.		0.02
Oil and grease—		
(14 gal. oil per yr. @ $0.1625 per gal.) ÷ 275 days	$0.008	
(15 lb. gear grease ÷ $0.045 per lb.) ÷ 275 days	0.002	0.01
Power input— (Tests on 40-hp. motor show input running idle 4 kw., and input on average cut 44 kw.) Running time, with load, approximately 70%; no load 30%. (5.6 hr. × 44 kw.) + (2.4 hr. x 4 kw.)—256 kw. hr. 256 kw. hr @ $0.02 per kw. hr.		5.12
Total daily cost, excluding operating labor		$ 14.51
Labor—8 hr. × $0.58 per hr.		4.64
Total daily cost, with labor		$ 19.15
Unit Operating Costs		
Per hour—$19.15 ÷ 8 hr.		$ 2.39
Per piece, on typical jobs, under average working conditions		
Exhaust box—½ hr. @ $2.39	$1.20	
Stoker engine plate—1¼ hr. @ $2.39	2.99	
Guide bar—1 hr. @ $2.39	2.39	
Die blocks (pair) — 1 hr. @ $2.39	2.39	
Grinding shear blades—⅔ hr. @ $2.39	1.59	

*Allowing for interest earned by depreciation reserve.

The cost of operating the grinder is given in Table B. Depreciation on the first cost, plus installation expense, is figured at 10 per cent and average interest is calculated at 6 per cent. The actual repair cost, aside from general maintenance, has to date been very small. The estimated allowance of 3 per cent per year should more than cover all future repair costs.

The daily fixed cost, based on 275 operating days a year is $5.04. To this are added the costs of grinding wheel, grinding solution, oil grease and power. The average power input was determined on the basis of actual tests. The tests showed the idling input to be 4 kw., and average cutting input to be 44 kw.

The total daily cost excluding operating labor, amounts to $14.51. Adding the operating labor, the total daily cost is $19.15—an average of $2.39 per hour.

Table B also shows the costs of facing several typical parts. Calculations are based on the unit rate determined in Table B, using the number of hours per piece indicated in Table A. A new exhaust box shows a cost of $1.20; a stoker engine plate $2.99; an average guide bar $2.39; a set of die blocks $2.39; and a pair of shear blades $1.59.

Table C indicates some of the time savings effected by employing the grinder. The table shows how the work was previously done, the former time to do the job, the present average total time, the time saving in hours, and the percentage reduction in time. The range in time reduction is 33.3 to 50 per cent.

TABLE C

Name of Part	How Formerly Done	Machine Time—Hours Former	Present	Time Saved (Hr.)	%
Exhaust boxes	Bore Mill	New box—1 hr.	½ hr.	½	50%
		Old box—½ hr.	¼ hr.	¼	50%
Die blocks (Pair)	Old grinder	2 hr.	1 hr.	1	50%
Shears	Old grinder	1 hr.	⅔ hr.	⅓	33.3%
Guides	Old grinder	2 hrs.	1 hr.	1	50%

The machine could be used for many other parts, but the amount of work now handled, on the parts mentioned, keeps the operator busy full time. The grinder has occasionally been used on the night shift also and its operation has been satisfactory in all respects.

Pennsylvania's New Track Scales

The Pennsylvania Railroad has completed the installation, in the Juniata Freight Yards at Altoona, Pa., of a twin pair of plate fulcrum track scales, which, taken together, constitute the largest and most modern plant for weighing carload freight in service on any railroad. These gigantic weighing machines have a capacity of 800,000 pounds each, yet with balances so sensitive that the weight of a single person can be determined within five pounds.

Located between the receiving and classification yards, the scales weigh all cars while in motion during the process of classification into trains. This combination of operations results in a considerable saving of time and greatly increased efficiency in yard movement.

During exhaustive tests the new scales achieved a speed record by weighing an average of five cars per minute, despite the fact that the weigh-masters had not become thoroughly familiar with the new apparatus. Some cars were weighed accurately in as brief a time as five seconds while passing over the scales.

Both scales are installed in a single roomy underground pit of heavy masonry construction. The weighing tracks are fourteen feet apart. Each weigh beam is enclosed by a plate glass bay window, affording an unobstructed view in all directions. Some idea of the massiveness of the scale structures may be gained from the fact that the weight of each weigh bridge alone is 73½ tons.

An especially designed lighting system makes possible continuous day and night operation. The masonry pit which houses all of the scale parts is kept heated during the winter, and a uniform temperature is thermostatically maintained. This is necessary in order that the apparatus may not be affected by variations resulting from extreme temperature changes.

What Railways Do in One Hour

An hour is a relatively short time, yet within that brief period the railways of the country perform a service for the public, on the average, of amazing volume.

Some of the work done in an hour by Class I lines is shown below, based on the figures of 1926 operations. It should be realized, of course, that the figures are averages.

In an hour, the railways receive gross revenues amounting to $728,251 from their transportation operations.

In an hour, the railways pay $336,632 in wages. (Much of this total is included in operating expenses.)

In an hour, the railways spend $196,046 in other operating expenses.

In an hour, the railways pay $44,370 in taxes to national, state and local governments.

In an hour, 6,086 cars are loaded with revenue freight on the railways' lines.

In an hour, 152,572 tons of revenue freight are loaded into freight cars.

In an hour, 98,213 passengers board the railways' trains.

In an hour, the freight service performed by the railways is equal to hauling 50,689,328 tons of freight for the distance of one mile.

In an hour, the passenger service performed by the railways is equal to hauling 4,051,019 passengers for the distance of one mile.

Notes on Domestic Railroads

Locomotives

The Erie Railroad has ordered 15 locomotive tenders from the Baldwin Locomotive Works.

The Detroit & Toledo Shore Line contemplates buying four eight-wheel switching locomotives.

The Alabama, Tennessee & Northern Railroad is inquiring for three locomotives.

The Southern Pacific Company is expected to enter the market for 30 locomotives.

The New York Central Lines is inquiring for 10 electric freight locomotives with an option on ordering 32 additional electric locomotives.

The South African Railways are inquiring through the locomotive builders in this country for 125 locomotives—60 to be Mallets and the balance of various types.

The Belt Railway of Chicago has ordered five 8-wheel switching type locomotives from the Baldwin Locomotive Works.

The Great Northern Railway has ordered 6 electric locomotives from the Westinghouse Electric & Manufacturing Company, at a cost of about $1,000,000. These locomotives are to be duplicates of those placed in operation this spring and will be built jointly by the Baldwin Locomotive Works and the Westinghouse Electric & Manufacturing Company.

The Walter A. Woodard Lumber Company, Cottage Grove, Ore., has ordered one Prairie type locomotive from the American Locomotive Company.

The South African Railways Administration is asking for bids from locomotive builders for one electric freight locomotive.

The Mukden-Hailung of China has ordered through Mitsui & Co., New York, 2 Mikado type locomotives from the American Locomotive Company. An order for 4 Mikado type locomotives has also been placed by the Baldwin Locomotive Works.

Freight Cars

The Carnegie Steel Company is inquiring for from 16 to 24 metal cars of 70 tons capacity.

The Great Northern Railway will build 200 box cars in its own shops.

The Northern Pacific Railway is inquiring for 200 steel underframes for new flat cars to be built in its own shops

The Tennessee Coal, Iron & Railroad contemplates building 45 ore cars of 50 tons capacity in its own shops.

The Pettibone Mulliken Company has ordered one flat bottom steel gondola car of a capacity of 50 tons from A. V. Konsberg.

The Western Maryland Railroad will make repairs to 1,000 freight cars in its own shops.

The Cities Service Company, New York, has ordered for its subsidiary the Empire Gasoline Company, 100 tank cars of 8,000-gal. capacity, from the American Car & Foundry Company.

The Carnegie Steel Company has ordered 40 tank cars from the American Car & Foundry Company.

The Cordova Central Railway of Argentine is in the market for 100 steel box cars.

The Pere Marquette Railway is inquiring for from 500 to 1,000 box cars of 40 tons capacity.

The New York, New Haven and Hartford Railroad is repairing about 2,000 freight cars at the company's shops.

The Cudahy Packing Company, Chicago, is inquiring for 200 refrigerator cars.

The Norfolk & Western Railway will build 250 all-steel automobile box cars at the company's shops at Roanoke, Va. Materials for these new cars will be ordered immediately and actual work on their construction should begin in about two months. The cars will be turned out at the rate of approximately six a day until the order is completed. The new cars are practically the same as the older type of standard automobile box car now in service except in the height of the car and the size of the door opening.

Passenger Cars

The Reading Company has ordered 5 combination baggage and mail cars from the American Car & Foundry Company and 5 from the Bethlehem Steel Company, and will build 2 express car in its own shops.

The Department of Commerce, Bureau of Mines, has ordered one all-steel mine rescue car from Hotchkiss, Blue & Co., Ltd.

The Lehigh Valley Railroad has ordered 4 steel dining cars and 2 steel club-dining cars from the Pullman Car & Manufacturing Corporation.

The Lehigh & New England Railroad has ordered a gas-electric rail motor car from the J. G. Brill Company. The electrical equipment will be supplied by the Westinghouse Electric & Manufacturing Company. The car will have seating capacity for 81 passengers.

The Southern Railway is inquiring for both a business car and also a business dining car.

The Chicago Great Western Railroad is inquiring for 4 combination baggage and mail cars.

The Richmond, Fredericksburg and Potomac Railroad is inquiring for one gas-electric rail motor car.

The Bolivian Government Railways are inquiring for three steel underframe sleeping cars, 50 feet long.

The Southern Pacific Company has ordered 6 combination baggage and mail cars from the Pullman Car & Manufacturing Corporation.

The Great Northern Railway has ordered one combination passenger, baggage and mail, gas-electric rail motor car, from the J. G. Brill Company.

The Consolidated Railways of Cuba contemplates purchasing three sleeping cars.

The Lehigh Valley Railroad has ordered 1 gas-electric rail motor car and 1 trailer car from the American Car & Foundry; 1 gas electric rail motor car and 2 trailer cars from the Bethlehem Steel Company, and 1 gas-electric rail motor car and 1 trailer car from the Osgood-Bradley Car Company.

Buildings and Structures

The Canadian Pacific Railway has let a contract for the construction of a four-stall brick roundhouse, a sand house and a cinder pit at Wetaskiwin, Alta., to J. H. Simmons, Winnipeg, Man.

The Pennsylvania Railroad has awarded a contract to the Pittsburgh-Des Moines Steel Company of Pittsburgh, Pa. for the construction of a pumping station at Edgeworth, Pa., which is estimated will cost $61,000.

The Baltimore & Ohio Railroad has let a contract to Milo P. Hanke of Cincinnati, O., for the construction of water treating plants at Wellsboro and McCool, Ind., to cost $34,000.

The Chicago, Rock Island & Pacific Railroad has bids closed on August 31 for the construction of extensions to five stalls of the roundhouse at Herington, Kan. This work is estimated to involve an expenditure of about $20,000.

The Chicago, Burlington & Quincy railroad has received bids for the construction of extensions to 7 stalls of its roundhouse at Western avenue, Chicago, Ill.

The New York Central Lines has ordered a 90-in. quartering and crank pin turning machine from the Niles-Bement-Pond Company.

The Central Vermont Railroad has awarded a contract to the Roberts & Schaeffer Co., Chicago, Ill. for the construction of an "N & W" type cinder plant at Burlington, Vt.

The St. Louis-San Francisco Railway has let general contracts for the construction of a machine shop, power house, wheel shop and wash room and locker building at Yale, Tenn., to J. H. Reddick, Fort Smith, Arkansas.

The Missouri Pacific Railway has ordered from Roberts & Schaeffer Co., the construction of two two-track "N & W" type cinder handling plants at Ewing avenue, St Louis, Mo.

The Chicago & North Western Railway has placed a contract with G. A. Johnson & Son for the Construction of an extension of 5 stalls of its roundhouse at Nelson, Ill.

The New York Central Lines has awarded a contract to the National Boiler Washing Company, of Chicago, Ill., for a boiler washing system in the new engine house at Harmon, N. Y.

The New York, New Haven & Hartford Railroad has awarded a contract to the Roberts & Schaeffer Co., for a 200-ton capacity reinforced concrete automatic electric locomotive coaling plant and an "N & W" type cinder handling plant at Lamberton street, New Haven Conn.

Supply Trade Notes

A. C. Turtle has joined the staff of the **Holden Company, Limited**, at Montreal, Que. Mr. Turtle was first with the Canadian Pacific Railway Company at their Winnipeg shops until March, 1914, following which he was engaged at the Transcona shops of the Grand Trunk Pacific Railway Company, where he occupied various positions for about twelve years. Subsequently, he was chief engineer of the **Western Engineering Company**, Limited, at Winnipeg, Man.

P. B. McGinnis has been appointed Representative of the **Westinghouse Friction Draft Gear Company** with headquarters at Chicago. Mr. McGinnis was in the employ of the **Westinghouse Air Brake Company** as Representative in Chicago until 1925, when he resigned to accept service with a well known automotive company. He now re-enters the Westinghouse organization.

W. E. Brown has been made district sales manager of the **General Electric Company** at New York.

H. H. James, engineer with the **Pittsburgh Plate Glass Company** at Zanesville, Ohio. He was previously on the staff of the **American Steel and Wire Company** at Donora, Pa., prior to which he was for a number of years with the Montreal Locomotive Works in the office of the maintenance engineer.

B. T. Anderson has been made assistant vice-president of the **Union Switch & Signal Company**, Swissvale, Pa. Mr. Anderson was formerly superintendent of signals for the Chesapeake & Ohio Railway.

George R. Berger has established an office at 110 So. Dearborn St., Chicago, and will represent a number of concerns dealing in railway supplies. He recently resigned as western manager for the **Gould Car Lighting Corporation.**

O. D. Kinsey, formerly tool supervisor of the Chicago, Milwaukee & St. Paul Railway, has been made general manager of the **Sheldon Machine Company, Chicago.**

F. T. Whitney has been made general sales manager of the **Cohoes Rolling Mill Company**, Cohoes, N. Y. He formerly represented the concern in the philadelphia territory.

N. M. Forsythe has been appointed Representative of the Automotive division, **Westinghouse Air Brake Company**, with headquarters at Pittsburgh. Mr. Forsythe, after graduating from the University of Michigan, entered the service of the company as Inspector in the Automotive Division at St. Louis, which position he held until his new appointment.

The Vapor Car Heating Co., Inc. of Chicago, has taken over from the **Phillips Metallic Hose Company**, of Jackson, Michigan, the entire manufacture and sale of the Phillips Flexible Pipe Joint for use in place of rubber steamhose.

This flexible metal joint has been redesigned and is being made in 2 inch size to meet conditions brought about by required increase in supply of steam for long trains, and it is arranged for connecting either to 2 inch train pipe valves and couplers or the present standard 1½ inch valves and steam couplers. The redesigned joint will be known as the Vapor Company's "SMOOTH BORE" Conduit. The Vapor Company will continue to manufacture their other types of joints as required.

A. A. Hale has been made vice-president of the **Griffin Wheel Company**, Chicago, and **F. B. Film**, sales agent of the company, has been transferred from Chicago to Cleveland.

The Strauss Bascule Bridge Company, Chicago, has changed its corporate title to the **Strauss Engineering Corporation. Joseph B. Strauss** is president, and **Charles A. Ellis** and **Clifford E. Paine** are vice-presidents.

The Whitman-Barnes-Detroit Corporation has announced the following changes in the organization. **Thomas S. Poole** has been appointed Direct Factory Representative for the Southern States territory, succeeding **Fred A. Hardin,** resigned. Prior to the merger of the **Whitman-Barnes Manufacturing Company** and the **Detroit Twist Drill Co., Mr. Poole** was for several years associated with the Detroit Company, since which time he has very creditably represented the new corporation.

M. B. Snow, vice-president and director, has resigned and is succeeded by **Karl Kendig,** who is now vice-president and treasurer.

H. Z. Callender, sales manager, has been made secretary and sales manager.

H. B. Gardner has been appointed assistant to the resident vice-president of the **Westinghouse Air Brake Company** at New York. Mr. Gardner was graduated from Union College, Schenectady, New York, as a mechanical engineer in 1916. He served several years with the **Locomotive Stoker Company** in mechanical and commercial activities, and entered the employ of the Westinghouse Air Brake Company in 1923 as representative. In 1926 Mr. Gardner was made vice-president of the **Westinghouse Friction Draft Gear Company** with headquarters at Chicago, and leaves this position to accept the new appointment in the parent organization.

Consolidation has been announced of the **Industrial Works** of Bay City, Mich., and the **Brown Hoisting Machinery Company,** Cleveland, Ohio. The new company will be known as the **Industrial Brown Hoist Corporation. A. C. Brown,** president of the **Brown Hoisting Machinery Company,** will be president of the new corporation.

The Arch Machinery Company, Pittsburgh, Pa., now represents the **Elwell-Parker Electric Company,** New York, in the Pittsburgh territory. **J. P. Lyons** of the Atlanta, Ga., office has been transferred to the New York office, and has been succeeded by **F. W. Ream; J. S. Cothran** is now Representative at Charlotte, N. C.

H. H. Straus has been elected vice-president of the **Inland Steel Company,** Chicago.

The Blaw-Knox Corporation will remove its New York office from 30 East 42nd Street to the Canadian Pacific Building at 342 Madison Avenue on October 1.

H. B. Bibb has been appointed sales manager at Norfolk, Va., for the **Graybar Electric Company.**

J. F. Craig, for four years Representative of the **Westinghouse Air Brake Company** at New York, has been promoted to the position of assistant eastern manager. Mr. Craig was graduated from Cornell University with the Mechanical Engineering Class of 1912. He entered the Experimental Department of the Westinghouse Air Brake Company in 1913, and left the employ of the company in 1916 for a time, engaging in engineering work and serving in the army during the World War. He re-entered the service of the Air Brake Company in 1920 as Special Engineer, with headquarters at Pittsburgh, and was transferred to the New York Office as Representative in 1923, which position he held until the time of his recent promotion.

M. L. Bardach, formerly president of the **Bardach Iron & Steel Company** of Norfolk, Va., has been appointed sales manager for the railroad department of **the Columbia Machine Works & Malleable Iron Company,** Brooklyn, N. Y.

The Waugh Equipment Company, Chicago, has appointed **The O'Fallon Company,** St. Louis, Mo., as exclusive representatives to handle the sales and distribution of their products in St. Louis and the middle-west.

R. L. Wilson, works manager of the East Pittsburgh, Pa., works of the **Westinghouse & Electric Manufacturing Company,** has been appointed assistant to vice-president and general manager, and **J. M. Hipple,** formerly manager of the motor engineering department of the company, succeeds Mr. Wilson as works manager.

Items of Personal Interest

E. B. Hall, superintendent of motive power of the Chicago & Northwestern Railway, with headquarters at Chicago, has been promoted to general superintendent of motive power and machinery, to succeed **H. T. Bentley,** who has retired under the pension rules of the company. **H. L. Harvey,** assistant superintendent of motive power and machinery, with headquarters at Chicago, will succeed Mr. Hall.

N. Suhrie, road foreman of engines, Williamsport Division of the Pennsylvania Railroad, has been appointed supervisor of fuel, at Philadelphia, Pa.

A. Bias has been made car foreman of the Chesapeake & Ohio Railroad at Handley, W. Va.

F. E. Boehm, traveling engineer, New York Division, has been appointed road foreman of engines, Fort Wayne Division of the Pennsylvania Railroad, succeeding **E. A. Burchiel.**

M. L. Trumpower, assistant road foreman of engines, Cumberland Valley Division of the Pennsylvania Railroad, has been appointed road foreman of engines, Williamsport Division, succeeding **N. Suhrie.**

A. A. King has been made road foreman of engines of the Atchison, Topeka & Santa Fe at Galveston, Texas, and **F. T. McClure,** at Ottawa, Kan., as road foreman of engines.

C. R. Sheckler, assistant road foreman of engines, Ft. Wayne Division of the Pennsylvania Railroad, was promoted to road foreman of engines, Logansport Division.

W. T. Abbington has been made master mechanic of the Missouri Pacific Railroad at Little Rock, Ark.

E. C. Roddie has been appointed shop superintendent of the Illinois Central Railroad at Paducah, Ky. He was formerly master mechanic at McComb, Miss., where he is succeeded by **J. N. Chapman.**

D. **H. Jenness,** road foreman of engines, Logansport Division of the Pennsylvania Railroad, has been transferred to position of road foreman of engines, Columbus Division, vice **C. S. White,** transferred to the position of Inspector, office of general superintendent, motive power, Chicago, Illinois.

A. A. Edmonston has been made road foreman of engines on the Shenandoah Division of the Norfolk & Western Railroad, succeeding **J. N. Clove,** transferred to the motive power department.

O. D. Kinsey has resigned as tool supervisor of the Chicago, Milwaukee & St. Paul to become general manager of the **Sheldon Machine Co.,** 3253 Cottage Grove Ave., Chicago, Ill.

John C. Gunning has been appointed roundhouse foreman of the Union Pacific Railroad at Ogden, Utah.

W. W. Wickline has been appointed to position of road foreman of engines, Sewell Valley Sub-Division, of the Chesapeake & Ohio Railroad, with headquarters at Rainelle, W. Va., succeeding **A. M. Simms,** assigned to other duties.

George I. Wright, assistant electrical engineer of the Illinois Central Roailroad with headquarters at Chicago, has been appointed engineer of electric traction of the Reading, with headquarters at Philadelphia, Pa.

Phillip I. Shipman has been made boiler foreman of St. Louis & San Francisco, at Memphis, Tenn., and **O. L. Baker** has been made machine shop foreman at Lindenwood, Tenn.

J. S. Hagen has been appointed electrical engineer of the Central Railroad of New Jersey, with headquarters at Elizabethport, N. J.

B. Pendleton has been made general foreman of the Canadian Pacific Railway shops at Montreal, succeeding F. Stewart, transferred.

M. A. Smith, assistant superintendent of motive power of the Pittsburgh & Lake Erie and the Lake Erie & Eastern Railroads, with headquarters at McKees Rocks, Pa., has been appointed superintendent of motive power, with headquarters at Pittsburgh, Pa. **David J. Redding** has been placed on the retired list. **Kar. Berg,** shop superintendent at McKees Rocks, has been appointed assistant superintendent of motive, with same headquarters, succeeding Mr. Smith. **H. G. Courtney,** mechanical engineer at Pittsburgh, has been appointed shop superintendent at McKees Rocks, succeeding Mr. Berg, and **C. H. McConnel,** electrical engineer at Pittsburgh, has been appointed mechanical engineer with the same headquarters, succeeding Mr. Courtney.

Thomas Waddell has been made boiler foreman of the Missouri Pacific Railway at Van Buren, Ark.

G. G. Shafer has been appointed assistant foreman, Altoona Machine Shop of the Pennsylvania Railroad at Altoona, Pa.

Obituary

Ernest B. Perry, president of the Industrial Works, Bay City, Michigan, nationally known manufacturers of cranes, passed away at his home 2230 Center Avenue, Sunday, August 7, after an illness of one week.

Mr. Perry was a director in the First National and Bay County Savings banks and was well known not only in Bay City but throughout industrial centers of the nation, through his long association with the Industrial Works. He helped build that company up to its present size since he first came there as chief engineer in 1889, after graduating as a mechanical engineer from the University of Michigan.

Ernest Blackman Perry was born in Prairie Du Chien, Wis., December 9, 1868. He was a son of Walter Scott Perry and Emma Blackman Perry. Mr. Perry received his early education in the public schools of Ann Arbor, Michigan, and when this was completed he entered the University of Michigan

He was enrolled in the mechanical engineering department and was graduated with the degree of Bachelor of Science from that department in 1889. In 1896 he received his master's degree in Mechanical Engineering. While a student at the university he became a member of the Delta Upsilon fraternity and, later, the Tau Beta Pi, national honorary engineering fraternity.

In 1889 he took a position with the Industrial Works as draftsman and was connected with that firm from that time on. In 1891 he was made superintendent and mechanical engineer and, later, vice-president and general manager.

In 1924 he came into the highest position the company could give him, that of the presidency of the concern. He served in that capacity until his death.

On November 22, 1889, he was married to Susie I. Harwood, of Ann Arbor. To them were born two children, both of whom survive: Harold H. Perry, one of the managing heads of the Industrial Works; and Ernestine H. Perry.

He was a member of the American Society of Mechanical Engineers and was affiliated with various other national organizations. He also was a member of the Rotary Club, of Bay City. He was a director of the Research Department of the University of Michigan, as well as a trustee of the University Alumni fund, and through this and other connections he was prominent among those identified with that school's activities.

New Publications

Books, Bulletins, Catalogues, etc.

Test of the Fatigue Strength of Cast Iron. By Herbert F. Moore, Stuart W. Lyon and Norman P. Inglis. This bulletin is issued by the Engineering Experiment Station of the University of Illinois. For your convenience a brief review of the bulletin is given herewith.

Until the present time very few test data have been published regarding the capacity of gray cast iron to resist repeated stress. The University of Illinois, therefore, in cooperation with the Allis-Chalmers Manufacturing Company of Milwaukee, Wis., undertook to make a series of fatigue tests on cast iron. The work was done in the laboratories of the Investigation of the Fatigue of Metals at the University of Illinois, and the results are published in Bulletin No. 164 of the Engineering Experiment Station.

In the investigation two distinct problems were recognized: (1) the study of the strength of cast iron as a material, and (2) the study of the effective strength of the material in different parts of a casting. The results in general may be considered as contributions to the study of the strength of cast iron as a material, although one series of tests was made on specimens cut from the inner wall of a large iron cylinder with double walls.

Static tests, impact tests, and fatigue tests were made on specimens from four different lots of gray cast iron, designated as cast irons 91, 92, 93 and 94. Cast iron 91 was from a piece of 6-in. pipe with walls ½ in. thick, cast iron 92 from a casting in the form of a 12-in. hollow cylinder with walls 1 in. thick, cast iron 93 from a casting in the form of a 12-in. cylinder with walls 3¼ in. thick, and cast iron 94 from the inner wall of a double walled cylinder casting weighing about 25 tons.

The results of the tests should be regarded as giving some suggestive information concerning the fatigue strength of cast iron rather than as giving comprehensive test data.

Copies of Bulletin No. 164 may be obtained without charge by addressing the Engineering Experiment Station, Urbana, Ill.

A Study of Fatigue Cracks in Car Axles. By Herbert F. Moore. This bulletin is issued by the Engineering Experiment Station of the University of Illinois. A brief review of the bulletin is given herewith.

Bulletin No. 165, entitled "A Study of Fatigue Cracks in Car Axles," contains the report of an investigation carried on by the University of Illinois in co-operation with the Utilities Co-operative Research Committee.

The tests reported in this bulletin, which is a report of progress, are believed to give some significant information concerning the appearance and spread of fatigue cracks caused by repeated stress in car axles and a general idea of the probable effectiveness of systematic inspection for incipient fatigue cracks.

With the use of a rotating-beam type of testing machine, fatigue cracks were produced in specimens cut from car axles. The critical diameter of these specimens was about one inch, and under various conditions of stress a study was made of the progress of fatigue cracks from their first appearance to the complete facture of the specimen.

Fatigue cracks were detected by the use of a low-power microscope, and also by the discoloration of a coating of whiting on the specimen by oil squeezed out of a crack when the specimen was subjected to bending stress. The oil and whiting method is one used in shop practice.

Copies of Bulletin No. 165 may be obtained without charge by addressing the Engineering Experiment Station, Urbana, Illinois.

The Gold Car Heating & Lighting Company, of 220 36th Street, Brooklyn, N. Y., has issued a 64-page catalogue on the subject of electric heating for railway cars, embracing electric heaters with both open coil and enclosed types of heating elements.

Their study and research on the subject of enclosed types of heating elements is fully described and should be interesting to those contemplating the use of this type of equipment. Copy will be mailed upon request.

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

Vol. XL — 136 Liberty Street, New York, October, 1927 — No. 10

New 2-8-4 Type Locomotives for Freight Service On the Erie Railroad

Booster Equipped, They Develop 81,700 Lbs. Tractive Effort

New 2-8-4 Type Locomotive of the Erie Railroad—Built by the American Locomotive Company

The twenty-five locomotives now being delivered to the Erie by the American Locomotive Company represent the solution of a typical railway traffic problem of today.

For the particular requirements in this case the type selected was the 2-8-4 combined with basic proportions all contributing to an assembly having as its primary purpose, to produce more ton miles per train hour with minimum fuel consumption.

When it is considered that these locomotives develop normally a tractive power of 70,000 lbs., using superheated steam at 225 lbs. pressure with 28½ x 32 in. cylinders and 70 in. drivers, a good idea of their size and power as movers of heavy freight at high speed is obtained. Although large drivers have previously been used on other types of locomotives in freight service, these engines are unique in being the first to use this size of driver in this wheel arrangement.

The locomotives are being placed in main line service and operate between Marion, Ohio, and Hornell, N. Y. The western end of the run is over two districts which extend from Marion, Ohio to Meadville, Pa., a distance of 203 miles. The ruling grades eastward are 1.295 per cent between Marion and Kent, and one per cent between Kent and Meadville. Westbound, the grades are one per cent between Meadville and Kent, and 1.315 per cent between Kent and Marion. East of Meadville the ruling grades in both directions, exclusive of pusher grades, are .20 per cent between Meadville, Pa., and Salamanca, N. Y., and .30 per cent between Salamanca and Hornell. In fast freight service some of these locomotives are being tried on continuous runs between Hornell, N. Y., and Marion, Ohio.

The adhesive weight of 276,000 lbs., or 69,000 lbs., on each driving axle and the 100 in., outside diameter of boiler at throat, on a center line 128 in., above the rail, indicate that full advantage has been taken of the strength of the track and the clearances, which on the Erie, are large for lines in the East.

The boiler is straight top 90 in., inside diameter at front and contains 242 3½ in. flues, and 50 2¼ in. tubes, 21 ft. long. Elesco type E superheater is used having 112 units. The firebox is 150 in. long by 96¼ in. wide, inside of sheets, giving a grate area of 100.2 sq. ft. It is fitted with two Nicholson Thermic Syphons and an American Security Brick Arch carried on two arch tubes and the syphons. The fuel is soft coal.

The overhanging weight in rear of the drivers resulting largely from this size of firebox and aggregating 120,000 lbs. on the trailer at the rail, demanded the use of the four wheel type of trailer. Accepting the theory that larger grates and fireboxes are necessary to producing high, sustained, boiler horsepower economically, their use in combination with four wheel trailing trucks is becoming more extended. The resemblance to the long popular Mikado type of locomotive is at once apparent, the additional pair of wheels creating a type which may be said to be the big brother of the Mikado, and characterized as distinctly modern.

One of the specified requirements was that the boiler develop not less than 100 per cent of the cylinder horsepower at a piston speed of 1,000 ft. per minute. To accomplish this, a total of 5,699 sq. ft. of evaporating surface is provided, divided as follows: 960 sq. ft. in the tubes, 4,290 sq. ft. in the flues, 320 sq. ft. in the firebox, 22 sq. ft. in the arch tubes and 107 sq. ft. in the syphons. The fuel is fed to the grates by Duplex stokers, and Worthington feed water pumps are applied.

The total weight in working order is 443,000 lbs. divided as follows: 47,000 lbs on the two wheel leading truck, 276,000 lb. on drivers and 120,000 lb. on the trailer.

At normal tractive power, the factor of adhesion is 3.94. The 11,700 lbs. additional tractive power furnished by the booster gives a factor of adhesion of 5.34 for the trailer.

The total wheel base of the engine is 42 ft. 0 in. of which 18 ft. 3 in. is the driving wheel base and 12 ft. 2 in. the rigid wheel base. In order to easily traverse the specified 20 deg. curves, Alco lateral motion device is applied to the front pair of drivers.

Steam is admitted through a shutoff valve in the dome and its supply to the cylinders, governed by an American Type Throttle incorporated in the superheater header. The piston valves are 14 in. diameter having 1¾ in. steam lap, and line and line exhaust, actuated by Baker Valve Gear having 9 in. travel, ¼ in. lead and a maximum of 80% cutoff. The locomotives are equipped with the Precision reverse gear.

The boiler is designed for a possible working pressure of 235 lbs. and the machinery for a possible pressure of 230 lbs. per sq. inch.

The leading truck is the Commonwealth Steel Co.'s type of outside bearing truck using MCB type of axles and bearings.

The tender which has a capacity of 16,500 gallons of water and 24 tons of coal, is carired on two Commonwealth six wheel trucks with clasp brakes. The wheels are 33 in. diameter and the journals 6 x 11 in. The tender frame is the Commonwealth water bottom type. The loaded weight of the tender is 310,500 lbs. and the total wheel base of engine and tender 86 ft. 2¼ in. Engine and tender are finished with Duco.

Among the Alco specialties used on these engines are, the Alco weldless boiler brace, Alco flexible staybolts and extension stays with welded sleeves. Alco hand rail colums and flextite steam pipe casings.

Barco flexible metallic connections are used throughout. The Franklin spring type radial buffer and unit safety draw bar is used between the engine and tender. The principal dimensions and data are in the accompanying table.

Railroad	Erie
Type of Locomotive	2-8-4
Service	Freight
Cylinders, diameter and stroke	28½ in. by 32 in.
Valve gear, type	Baker
Valves, piston type, size	14 in.
Maximum travel	9 in.
Outside lap	1¾ in.
Lead in full gear	¼
Cut-off in full gear, per cent	80
Weights in working order:	
On driver	276,000 lb.
On front truck	47,000 lb.
On trailing trucks	120,000 lb.
Total engine	443,000 lb.
Tender	310,500 lb.
Wheel bases:	
Driving	18 ft. 3 in.
Rigid	12 ft. 2 in.
Total engine	42 ft.
Total engine and tender	86 ft. 2¼ in.
Wheels, diameter outside tires:	
Driving	70 in.
Front truck	33 in.
Trailing truck	36 in. 43 in.
Journals, diameter and length:	
Driving, main	13 in. by 13 in.
Driving, others	11½ in. by 13 in.
Front truck	6½ in. by 12 in.
Trailing truck	7 in. by 14 in. and 9 in. by 14 in.
Boiler	
Type	Straight top
Steam pressure	225 lb.
Fuel	Bituminous
Diameter, first ring, inside	90 in.
Firebox, length and width	150 in. by 96¼ in.
Height mud ring to crown sheet, back	76⅝ in.
Height mud ring to crown sheet, front	96⅝ in.
Combustion chamber length	None
Tubes, number and diameter	50, 2¼ in.
Flues, number and diameter	242, 3½
Length over tube sheets	21 ft.
Tube spacing	4¼ in.
Flue spacing	3 in.
Grate type	Rocking
Grate area	100.2 sq. ft.
Heating surfaces:	
Firebox and comb. chamber	320 sq. ft.
Arch tubes and syphons	129 sq. ft.
Tubes	960 sq. ft.
Flues	4,290
Total evaporative	5,699 sq. ft.
Superheating	2,448 sq. ft.
Comb. evaporative and superheating	8,147 sq. ft.
Tender:	
Style	Rectangular
Water capacity	16,500 gal.
Fuel capacity	24 tons

Railway Executives to Visit Purdue Test Plant

Between 200 and 250 railway executives from throughout the U. S. and Canada are expected at Purdue University Nov. 11 to inspect the research work being conducted by the university's engineering experiment station for the American Railway Association on the testing of air brake equipment and draft gears. The air brake tests have been underway nearly two years under the direction of H. A. Johnson, director or research for the Railway Association, and also general manager of the elevated lines in Chicago. The draft gear tests were starter last spring under the direction of the Purdue Engineering Experiment Station.

For the purpose of the air brake tests, the air brake equipment equivalent of a 100 car train has been set up in the mechanical engineering laboratory at the university. Different equipments purchased from the airbrake manufacturers by the A. R. A. are tested under all sorts of conditions which have been made to compare to actual road conditions. They are tried on everything from a single car to as many as a 100 car train. Following completion of the laboratory tests, roadwork will be done on some line where very steep grades are encountered.

The draft gear tests were started to develop specifications covering the characteristics which draft gears should have and which it is hoped will greatly reduce the damage to freight cars and contents each year. A 27,000 pound weight is dropped from different heights onto the gears which absorb and dispel the energy developed when cars are bumped together in switching.

Besides inspecting this work, the visiting rail executives have been invited to hear Prof. A. I. Lipetz, consulting engineer for the American Locomotive Company, and nonresident professor of locomotive engineering on the Purdue staff. Prof. Lipetz will be at Purdue for a series of lectures to the engineering students Nov. 7 to Nov. 11. The rail executives will gather the afternoon of the 10th for a series of committee meetings and conferences and the following day will be given to the inspection of the research work.

The Application of Roller Bearings to Railway Cars*

Test Results in Starting, Accelerating and Running

By **WALTER G. SANDERS**, Manager, Railway Division, Timken Roller Bearing Company

The problem of applying antifriction bearings to railway service justifies a careful analysis, both from a technical and economic standpoint. First, because it is known that their use will mean not only a saving of power in regular operation, but also the elimination of hot boxes, and better running conditions generally. Second, because they will bring about the savings in lubrication, and maintenance expense as well as reduce the amount of wear and tear to which the rolling stock is subjected.

The problem of producing roller bearings that will stand up under the severe service on railway rolling stock has been a very difficult one. The solution required extensive tests and experiments; also the perfection of a suitable design of railway car truck equipped with roller bearings, required considerable time and numerous tests as all engineering progress is a constant refinement of existing designs.

The design must reflect general railroad practice as far as possible and must show economy in every way.

In order to successfully apply roller bearings to the journals of railroad equipment, certain conditions should be met as follows:

(a) The bearing must have a low frictional resistance for all service conditions.

(b) The bearing must have a long service life.

(c) The design of the bearing should be such that both vertical and thrust loads or any combination of these loads may be carried by the bearing proper.

(d) The application should be such that a quick inspection may be made.

(e) The application should be simple in construction and easy to assemble and disassemble.

(f) The bearing should be adjustable.

(g) The bearing must be durable in every way.

Many attempts have been made during recent years to solve for railways the problem of anti-friction journal bearings. Failures have ordinarily resulted from one or more of three causes:

First: The crushing strains under heavy loads and blows upon the surfaces of the metals in rotating members and raceways resulted in fatigue and fractures; second, the diagonal twisting and jamming of the rollers; third, the troublesome end thrust which may at times equal 40 per cent of the vertical load.

For the heavy combined vertical and thrust loads at high speeds, the tapered roller bearing principle seems essential to durability. Not only should the bearing perform the dual duty of taking radial and thrust loads, but in a railway roller bearing there must be no delicate, breakable, or complicated parts involving expensive renewals.

Railway mechanical engineers have made valuable contributions to the development of a successful bearing by showing what the requirements of the service actually were and by pointing out the weak spots in bearing design which were to be avoided. In other words there must be short lived features.

The extensive use of self-propelled gasoline coaches within the past few years has given considerable impetus to attempts to produce a practical bearing for railway service. Because of the limited power of the gasoline engine, it was necessary to take advantage of every possible means to improve the load characteristics of the car proper, especially with respect to starting and acceleration. Car designers turned to anti-friction bearings as a possible remedy. The application produced such remarkable results not only in accelerating and starting, but in the matter of fuel economy and general operation, that the bearing engineers were encouraged to continue their efforts to produce a bearing suitable for heavy railway service for by this time the requirements of the service was understood by them. They had also learned what would be necessary in the design and construction of the bearing itself.

The Tapered Roller Bearing Principle

The principal object of the tapered construction is to provide capacity in the bearing for the thrust loads, which exist in all railroad applications, with no appreciable sacrifice in vertical load carrying power. Fig. 1 shows a Timken roller bearing with an included cup angle of a little less than 24 deg. Assuming a load of 100 units *AB* applied radially or vertically to the roll, the normal pressure *CB* on the roll is 102 units. The thrust capacity of this particular roll is represented by the line *AC* and is equal to 20 units. By reason of the fact that only the top rolls in the bearing carry vertical load, the bearing has a thrust capacity almost equal to its vertical capacity. In other words, with an increase of two per cent in the normal load on the rolls under vertical loading, a thrust capacity equal to the vertical capacity is obtained. By varying the included cup angle the ratio of thrust to vertical or radial capacity can be changed over wide limits.

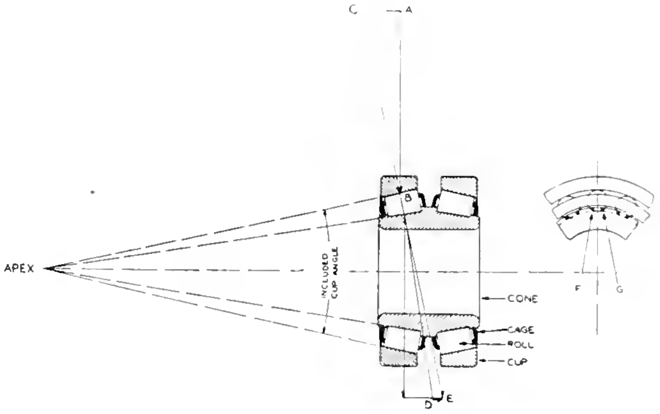


Fig. 1—Diagram Showing Thory and Design of Tapered Roller Bearing

Another advantage of the tapered construction has proved, however, to be quite as important as the provision for thrust loading. Operation of a roller bearing, particularly at the higher speeds, requires correct alinement of the rollers with respect to the axis of the bearing. If the rollers are not accurately alined, contact with the races over their entire lengths will not be obtained and dangerous concentration of stresses on small areas will result. In Fig. 1 the reaction of the roller against the rib on the inner races is represented by the line *DE*. The end of the roller makes contact with the rib on two areas *F*

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* Abstract of paper presented at the Seattle, Washington, meeting of the American Society of Mechanical Engineers.

and *G*. This double contact holds the rolls in positive alinement entirely independent of the cage and assures an equal distribution of stress over the length of the roll. The alining principle has been checked by operating bearings without cages at the highest speeds at which the bearings are required to operate in service. The cage acts as a roll spacer when in service and as a retainer when the bearing is stored or handled.

The tapered roller bearing is practically frictionless, the rolling resistance being less than three-tenths of one per cent.

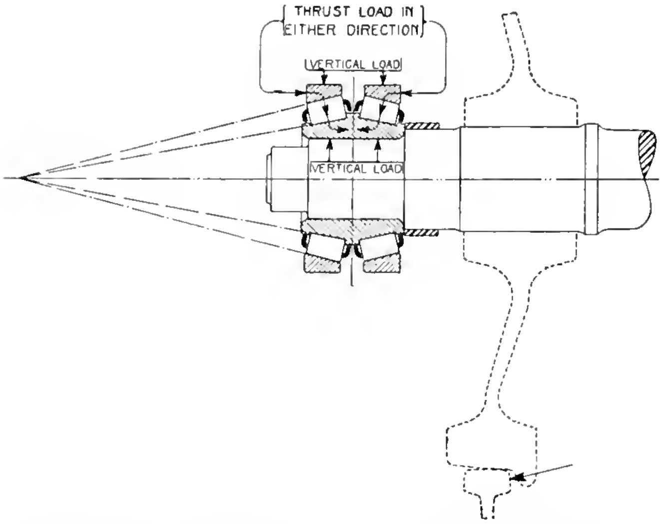


Fig. 2—Diagram Showing How Tapered Roller Bearing Carries Vertical and Thrust Loads and a Combination of Each in One Bearing

Fig. 2 shows how vertical and thrust loads and combinations of each are carried in a tapered roller bearing.

Adjustability of the Tapered Bearing

It is an indisputable engineering principle that, whenever two moving parts are in contact, wear must eventually occur. No matter how well the parts of any type of bearing are made, the constant motion, sooner or later, must result in wear.

The tapered roller bearing can be adjusted for the small amount of wear which may occur. This adjustment feature also provides wider tolerances for machine work on axles and bearing boxes.

The adjustment consists of moving the tapered outer raceway or cup a little farther on to the tapered roller assembly. The whole bearing will then function like new and replacement is eliminated. Tests show that in a tapered roller bearing the wear is negligible during the first several years of operation.

Bearing Equipment for Passenger Cars

Since the bearing now used on 62 Pullmans and 65 various other types of passenger cars on the Chicago, Milwaukee & St. Paul Railway is a typical railway application, its description will serve to cover essential characteristics.

The bearing consists of four main parts, the double cone, or inner raceway, two sets of tapered rolls, two cages, and two cups or outer races. The cone, which is common to both sets of rolls is formed with ribs at both outer ends, and is tapered up to a ribbed apex in the middle. The two sets of tapered rolls are assembled on the cone and are held to proper spacing by their respective cages. The two cups are then assembled over the rolls. The bearing is assembled in the housing and then pressed on the axle, after which the adjustment is made by shims.

The dimensions of the bearing for a 5 in. by 9 in. journal size axle are, bore 5 in.; outside diameter 11⅝ in.; and width of cone at its contact with the axle 6¼ in. The rated capacity of one bearing is 28,900 lb. vertical and 23,275 lb. thrust load, at 750 r.p.m. which with 36 in. wheels corresponds to 80 miles per hour train speed. The capacity of a 5 in. by 9 in. journal size axle is 32,000 lb., while the two bearings used per axle have an actual vertical capacity of 57,800 lb. at 80 miles per hour and 69,400 lb. at 500 r.p.m. or 53 miles per hour.

In the assembly the cone is mounted on an axle under a heavy press fit of from 20 to 30 tons. This will insure the cone remaining tight and prevent wear on the axle by creeping. The cups are given a press fit in the housing of 3 to 5 tons insuring against rotation or creeping in the housing.

The journal box proper consists of two housings, and the cover. For this reason it is generally called a double box or self alining application. The inside housing which contains the bearing is crowned at the top and bottom; the crown having about the same radius as the plain bearing box wedge, which gives the application the feature of self alinement. When the top is worn the housing may be rotated 180 degrees and a new alining surface will thus be brought in contact with the outside housing.

The enclosure is an integral part of the inside housing and consists of a series of annular grooves. It is placed over the axle sleeve which is also called the cone removal sleeve. The enclosure has a very small clearance with the sleeve in order to prevent leakage of the lubricant. The cone removal sleeve also serves the purpose of removing the bearing and box in case it is necessary to remove the wheel. As the wheel is pressed off the axle it comes in contact with the sleeve thereby pushing off the bearing and box.

Adjustment of the bearing is obtained by means of thin brass shims which are placed between the cover and the inside housing. Adjustment is maintained and the cover and outside cup are held in place by eight cap bolts spaced around the outside of the cover and housing.

One of the most important features of the design is the degree of flexibility possible in the application. It will be noted that there is a space on both ends of the inside housing between it and the outside housing. The wheels, axles and bearings may move this lateral distance relative to the truck and car body. This high degree of flexibility is essential for six wheel trucks and is also desirable for four wheel trucks.

As to load capacity requirements, the essential correctness of the tapered roller principle has been thoroughly demonstrated by the performance of bearings embodying this principle in many test applications where the severe character of the loads and shocks is even more marked than is the case in regular railway service. Durability is insured by the quality of steel used in the construction of all the load carrying members. The production of this steel is carefully controlled to secure a metal that is not subject to fatigue deterioration over long periods of severe service, and that will easily withstand all the crushing loads and shock that are likely to be incurred. Durability is also impaired by the construction that keeps the rollers properly alined at all times, and thus prevents failures from uneven wear, or faulty contacts and by the fact that the loads are carried on a comparatively large proportion of the surfaces of the different members; in other words, there is full line instead of point contact.

Comfort to Passengers

The author of this paper was a passenger on the first trip of the "Pioneer Limited" which was the first completely equipped roller bearing Pullman train in the history of American Railroads. The easy riding qualities were very noticeable and the train started and stopped with a yacht-like motion and without jerks. The change from standstill to motion on a roller bearing train is almost imperceptible.

It has been discovered that the ends of the cars have the same riding qualities as the center and ticket agents make good use of this fact in disposing of berths in the ends of the cars. The use of the roller bearing trains on the Chicago, Milwaukee and St. Paul Railway has been the means of an increase in passenger traffic. Passengers riding the "Pioneer Limited" between Chicago, and St. Paul-Minneapolis and the "Olympian," the transcontinental train between Chicago and Seattle-Tacoma, speak very highly of the superior riding qualities of the two trains.

It is true, of couruse, that the improved riding qualities are partly due to the tighter buffers and stiffer draft gears, which eliminate all slack between the cars. When starting, all cars start simultaneously with the locomotive. When brakes are applied, all cars come to a stop without slamming each other, regardless of how the braking force of one car may differ from another. Transverse shocks originating at the track are absorbed by a sliding motion between the inside and outside bearing boxes without producing appreciable side-motion in the car.

Eghteen cars were recently handled on the "Pioneer Limited" by a locomotive which formerly hauled 12 to 14 plain bearing cars.

Tests

Until recently there has been a general tendency to under-rate the retarding effect of journal friction and the power required to overcome friction in railway operation. It has been conclusively shown that the practical elimination of friction by roller bearings means a saving in power costs, and it is now becoming apparent that the weight of cars should not rest upon a sliding surface which will retard the rotation of the journal. Relatively, it is as important that the bearings should roll, as it is that the wheels should roll.

The energy consumed in hauling a train depends, of course, on the total resistance. This is composed of several factors such as journal friction, rail resistance, air resistance, grade and curve resistance, and that form of resistance which is caused by vibration or oscillation, all of which may vary considerably under different conditions of track, speed, weather, and train combinations.

The component parts of train resistance can be divided into two groups, namely:

(a) Resistances which will vary directly with the speed, comprising journal friction, rolling friction, flange action and track resistance.

(b) Resistances which increase with the square of speed, namely, all forms of air resistance.

The reaction between wheel and rail may be grouped under two heads, vertical and lateral. In the former category are rolling friction, track resistance, and impact at points. Lateral resistance is caused chiefly by what is called flange action and varies with the speed and cross winds.

When determining the reduction of resistance due to the use of roller bearings, it is usual to compare the total resistance of a train with plain bearings and one with roller bearings under similar conditions of train weight and speed, and the saving is usually expressed in percentage of the total energy consumed.

It is evident, however, that the roller bearing can only claim the saving effected in journal friction and less weight per truck and that the variation in resistance caused by any of the other factors has no bearing on the question. Tests have indicated that at all speeds below 36.5 miles per hour the resistance due to plain bearings is considerably in excess of that of roller bearings.

Considering the resistance caused by the journal friction on a railroad car with plain bearings, we can distinguish three different periods as follows:

1. Starting period.
2. Heating period.
3. Period of constant temperature.

The starting resistance is of importance, especially on roads with low grades, as it is the deciding factor in determining the size, weight and rating of the locomotive.

Mechanical friction constitutes a large element of train resistance and journal friction is so large a part of mechanical friction that all other elements of mechanical friction may be subordinated to it. Journal friction imposes a dead weight that must be overcome every time a wheel turns.

Tapered roller bearings were brought to their present stage of development only after a long and painstaking series of tests, both laboratory and service, which extended over a period of several years.

The first of these tests was conducted to obtain data on the comparative starting, acceleration, running and coasting of two standard railway freight cars, one equipped with tapered roller bearings and the other with plain bearings. The two cars were of the same series and identical in every respect with the exception of bearings. The roller bearing car had made 22,100 miles in main line service, and the other was selected at random from among the cars usually used by the same railroad that was operating the roller bearing car. Both cars underwent the test in the same condition as they were received from the railroad. The cars were loaded to capacity with steel billets. The following table gives the weights, light and loaded, that existed throughout the tests:

	Roller Bearing Car	Plain Bearing Car
Stenciled capacity	80,000 lb.	80,000 lb.
Weight unloaded	43,200 lb.	40,401 lb.
Load (Steel billets)	78,715 lb,	80,760 lb.
Total weight (car and load) ...	121,915 lb.	121,160 lb.

Figure No. 3 shows the results of the starting tests made between the two cars. The figure is self-explanatory but attention is invited to the fact that the ratio of the starting resistance of the two cars is 8.8 to 1 in favor of the roller bearing equipped car, as a saving in tractive effort at starting of 88.8 per cent.

The starting test was conducted by attaching one end of 3,000 lb. capacity dynamometer to the car and the other end to a block and tackle. Force was slowly applied to the block and tackle until the car started, at which instant the dynamometer reading was taken. A total of fifty-six readings in both directions were taken, at 30 second intervals. An average of the readings shows the following results:

Roller bearing car...........4.38 lb. per ton or
267 lb. total to start.
Plain bearing car...........38.59 lb. per ton or
2337 lb. total to start.
Ratio....8.8 to 1 in favor of roller bearing car

In the acceleration test each car in turn was hauled by a 300 H.P. plain bearing electric baggage car for a run of 20 seconds. Readings were taken as soon as the car started, and every five seconds thereafter. The average of results shows the acceleration in miles per hour per second for 15 seconds to be 0.69 for the roller bearing car, and 0.57 for the plain bearing car. Speed after 20 seconds was 10.54 h.p.h. for the roller bearing car and 8.75 m.p.h. for the plain bearing car. As to total distance traveled in

20 seconds that of the roller bearing car was 144.94 feet and of the plain bearing car 122.23 feet. The direct power saving during the run ranged from 28 per cent for the first 5 seconds to 18 per cent in 20 seconds.

The running test was made to determine the actual saving in power consumption of the roller bearing car. The test run was made over a stretch of track 28.30 miles long which included varied conditions of gradient and road bed. The cars were hauled by a 300 H.P. plain bearing electric baggage car and readings were taken every 15 seconds. The net results indicated a power saving of 17.4 per cent in favor of the roller bearing car.

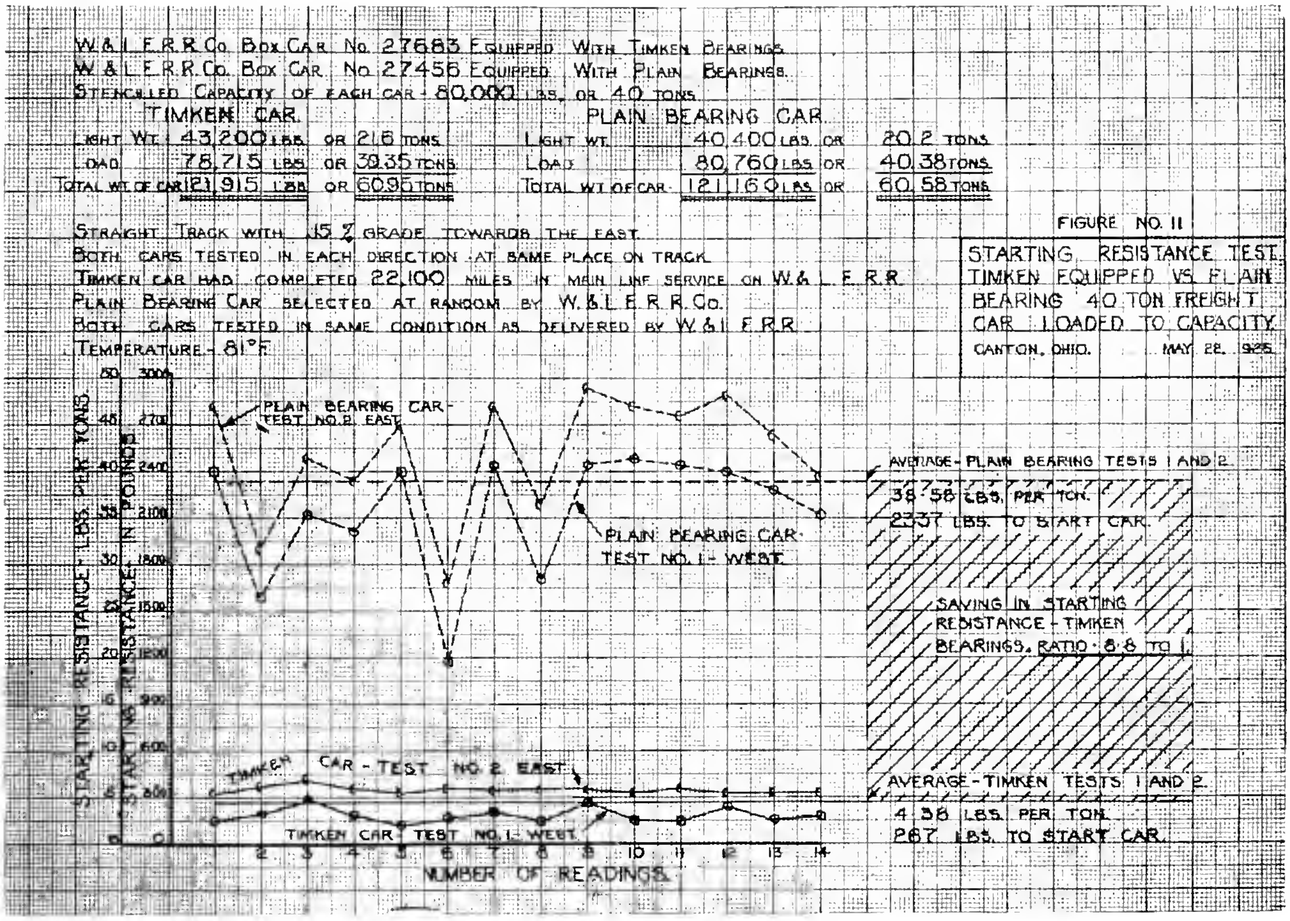


Fig. 3—Starting Resistance Tests of Tapered Roller Bearing and Plain Bearing Freight Cars of 40 Tons Capacity

The coasting test was conducted upon track which was in very poor condition and had numerous right and left and up and down grades. The down grade at the starting point was 9.25 per cent.

The roller bearing car started without assistance when the brakes were released while it was necessary to bump the plain bearing car three times with a locomotive before it would start. The roller bearing car coasted a distance of 7,200 ft. while the plain bearing car coasted 1,300 ft.

Another test which may be cited is of considerable interest, partly because of the results obtained in the matter of power consumption, and partly because of the light thrown on the effect of journal friction on train resistance. These tests were conducted with two gas-electric trains in revenue service operating over a stretch of over 200 miles, one being equipped with roller bearings and other with plain. The two trains were made up of cars as nearly identical in weight as possible, the actual totals being 172,360 lb. for the roller bearing and 169,780 lb. for the plain bearing train. The track on which the tests were run shows an average up grade in one direction of 0.056 per cent for one section, and 0.081 per cent for the other. The rail section was heavy and there was a high proportion of tangent track. Track maintenance and ballast were both good.

In the revenue service test graphic records were made of traction motor voltage and car speed, and the energy imput to the motors. On some grades the graphic meter records were checked by 10 second readings on indicating meters. As a further check an accurate record was kept of the time of each power application and cut-off of each brake application, and of the duration of every stop. In fact, every effort was made to make the test as accurate as possible.

A total of twenty-six tests were made and, without going into detail, it was found that, without considering corrections for windage, or different track conditions the overall power saving of the roller bearing train amounted to over 9 per cent on a gross ton-mile basis.

Other tests could be cited at considerable length, but since it would mean a duplication of results, these are considered sufficient to establish the case for rolling bearings. It can plainly be seen that under every condition where journal friction affects operating characteristics, the use of roller bearings results in considerable improvement. In the case of starting, acceleration, and coasting, the underlying reasons for the improvement can be explained as follows:

Take starting for example, a plain bearing train on a level track will require a draw bar pull of several hundred pounds to overcome the resistance on each journal, the brasses of the bearing acting as so many brake shoes until the oil film is produced. With roller bearing journals, this high resistance is eliminated, and the axle is free to turn when a very small amount of power is applied because the action is rolling and does not depend to such a great extent on the presence of an oil film. Tile sliding friction is replaced by rolling motion, which accounts for the difference in starting characteristics.

The same principles hold true in the case of acceleration and coasting. In the former case, the plain bearing will exert a braking action until the oil film is re-established, which takes at least sufficient time to make a noticeable difference in the accelerating period.

The difference between the two types of bearings during actual running at full speed is not nearly as great as it is at starting. When the percentage of power used in starting and accelerating a train is considered, and also the fact that coasting as much of the time as possible, is a highly desirable form of railway practice; the effect of the starting and acceleration characteristics on the value of the bearings as a power saver is quite appreciable.

Hot Boxes and Lubrication

An item of maintenance where roller bearings will effect a considerable saving is that of hot boxes. Hot boxes undoubtedly constitute one of the most troublesome conditions which vary widely not only on different railroads, but also at different seasons of the year. They are, of course, more common on freight than on passenger cars, due probably to the fact that passenger cars receive more frequent and better journal inspections.

The frequency of hot boxes or the number per 1,000 car-miles will vary considerably on different roads, due to the different conditions of operation. The cost to the road per hot box will also vary somewhat. One road has estimated that in passenger service a hot box costs approximately $30.00, which would indicate that a road operating several thousand passenger cars must have a large hot box expense.

The use of roller bearings will almost completely eliminate the troublesome hot box situation with all its attendan ills, effecting thereby a considerable saving to the road.

Grease of about the consistency of vaseline is being used as the lubricant for tapered roller bearings under railway cars. Bearing manufacturers have spent a large amount of money on the lubrication problems which were encountered in high speed railway service. When oil is used it is necessary to have an unfailing supply of a correct quantity. When a large quantity of oil is fed to the bearing, excessive heat is generated by the churning action. The resulting high temperatures thin out the oil, making it difficult to retain it in the housing, even with the best type of enclosure.

With roller bearings on cars, several items of lubrication expense are eliminated at the outset, and others are greatly reduced. Among those eliminated are, waste and the labor charge for packing it in the bearings. In addition there is no necessity for maintaining a waste reclaiming plant, so that this expense is eliminated in cases where it exists.

A check-up on the grease used in the bearings on the Milwaukee road's "Pioneer Limited" train, running between Chicago and St. Paul-Minneapolis for the month of July, 1927, disclosed that the cost of lubricant is much less for roller bearings than for plain bearings. The previous cost to lubricate the train on plain bearings averaged 22.5 to 26 cents per 1,000 car-miles. The cost of grease for the roller bearings on this train for July, 1927, averaged 15.8 cents per 1,000 car-miles. Further reduction in the lubrication costs on this train is expected.

Effect of Roller Bearings on Brakes

Another question which has been raised in connection with roller bearing operation should be considered here. That is, the effect of roller bearings on braking conditions. This may be briefly disposed of by stating they have in a general sense no appreciable effect. The braking effect depends only on the friction between the brake shoe and the wheel and the rail. The latter should always be more than the former.

There is this difference which should be considered, however; if power has been shut off and the train allowed to coast, it will have greater speed at a given point, and roller bearing cars will require more braking effort to stop when the limits are not predetermined. The engineman will have to apply his brake a short time sooner in order to stop at any desired point due to the difference between the journal resistance of the two types of bearings. Experience has shown, however, that stopping is much smoother due to the lack of the seizing action of the plain bearing at low speeds when the oil film breaks. The engineman should learn to shut off the power at the proper time and take pride in the coasting qualities of his roller bearing train.

Roller Bearings for Freight Equipment

While the application of roller bearings to passenger train equipment is receiving the greatest attention at the present time from the railroads, the greatest benefits will be obtained through their application to freight train equipment.

The company with which the author is associated has in successful operation a number of 50-ton and 70-ton freight cars embodying an entirely new type of inboard trucks. It is believed that this type of truck can ultimately be built by the car builders and railway including the roller bearings at a cost not greatly exceeding that of the existing type of freight truck. An inboard truck, is one having the bearings mounted in a housing on the axle inside the wheels, there being no journal boxes and bearings outside the wheels. The freight cars equipped with this type of inboard trucks, weigh appreciably less than the plain bearing freight cars, thus effecting a power saving because of their lighter weight as well as through the use of roller bearings.

In testing the inboard truck in the laboratory, one truck is turned upside down on the other and the wheels driven by means of a belt from an electric motor. The full axle load is applied and the trucks are operated continuously at speeds of from 45 to 65 miles per hour until something happens. The test has been frequently interrupted on account of failure of side frames, springs and wheels, but the performance of the bearings indicate them to be the most substantial component parts of the truck.

The desirable features of the design of the inboard truck are, first, a marked saving in weight due to the reduction in length and diameter of the axle and a reduction in length and cross section of the bolster and spring plank, and second, simplicity of design.

It is a fact that to whatever extent the non-productive weight of the car can be reduced, to that same extent the productive weight may be increased. As the expenditure of fuel in hauling a ton is the same, whether or not the latter is paying freight, it is evident that the smaller the percentage of non-paying freight or dead weight to the total weight moved, the smaller will be the cost of hauling the paying freight. It is, therefore, a means of increasing the efficiency of operation to decrease the non-productive weight of the car. The inboard type of truck will accomplish this, as well as affording all of the other advantages inherent to roller bearings.

The inboard type truck is still in the experimental and development stage, although the tests have progressed far enough and the results obtained have indicated that this type of design is very feasible.

The adoption of roller bearings for freight train cars, regardless of the design of truck, faces the difficult problem of interchange. However, so great are the potential savings, that there can be no question about finding a way to solve the interchange problem and put these savings into effect.

Summary

The advantages and savings made possible by the use of tapered roller bearings can be capitalized in different ways for different kinds of traffic. On freight trains it is best to increase the number of cars per train and use a correspondingly smaller number of trains. On passenger trains it is usually difficult to reduce the number of trains and the advantage here is mostly in handling more cars, in the saving in fuel, in comfort to passengers and in the elimination of delays caused by hot boxes.

Besides the saving in fuel, the freedom from overheated bearings is an item of great importance and should alone be sufficient reason for installing roller bearings on fast express trains.

Further, the use of roller bearings is advantageous from a maintenance standpoint in the matter of the upkeep and general durability of the bearings themselves, as compared to those of plain bearings. Opinions vary considerably as to the life of the various parts that go to make up the ordinary plain bearing, but estimates made by one representative railroad from data gathered on the performance of a number of passenger cars over a considerable period, may be taken as fairly significant.

These estimates give the life of the brasses at about 30,000 miles; of axles about 360,000 miles. Obviously, however, the brasses are the most expensive item of the three and cause the greatest amount of expense for replacement. On the other hand, the life expectation of a tapered roller bearing in passenger service should, under normal operating conditions be over a million miles, and this with a minimum amount of labor and money to keep it in running condition. The magnitude of the savings thus made possible in the case of railroad operating thousands, or even hundreds, of cars, can be easily imagined.

The other savings that may be expected are practically impossible to state in figures, or even estimates, because under most conditions it would be exceedingly difficult to trace them directly to their source in bearing operation. This statement refers principally to improvements such as reduced wear and damage to rolling stock resulting from better starting and accelerating conditions.

Since freight revenue rests entirely on a ton-mile-time basis, not much elaboration is necessary to bring out the full extent of the economic advantages of roller bearing trains. From the other aspect of railway operation, that of maintenance expense, roller bearings should also play a large part in improving existing conditions. Because of the wide variations in conditions on different railroads it is not possible at this time to make any accurate statement of just what percentage of reduction may be expected in the different items that go to make up a railroad's operating expenses. However, since some hitherto standard items will be eliminated altogether, it is possible to give some idea of what may be expected generally, from which deductions can be made in individual cases by those who are acquainted with the details.

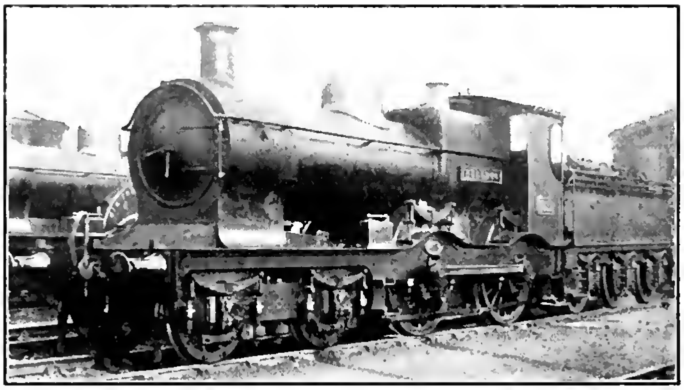
Any improvement in the design of the equipment used in the operation of railways that will show economies in the cost or improvement in the service is sought by the management of railways, and roller bearings will be growing factors in raising the standard of both equipment design and operating efficiency.

Motive Power of the Great Western Railway of England

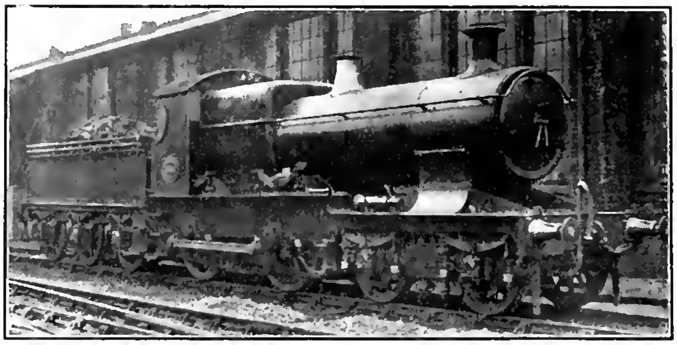
By Arthur Curran

The year 1927 will long be memorable as the centenary of the Baltimore and Ohio Railroad and as the occasion of a most courteous and gracious act of the Great Western Railway of England. Articles published in *Railway and Locomotive Engineering* during both 1926 and 1927 have called attention to motive power development on the G. W. R., and have, it is hoped, helped to an understanding of that unique system. There remain, however, one or two classes which deserve notice at this time, and one of them forms the subject of the present paper.

The "Bulldog" Class derives its name from the first engine of the series, which appeared in 1898. This engine is shown, as originally built, in an accompanying illustration. It will be seen that it had the old style outside frames, straight boiler barrel with dome, Belpaire firebox with safety-valve on roof shed, and short smoke-box of the old-time, familiar British type.


The "Bulldog" Class Locomotive of the Great Western Railway of England

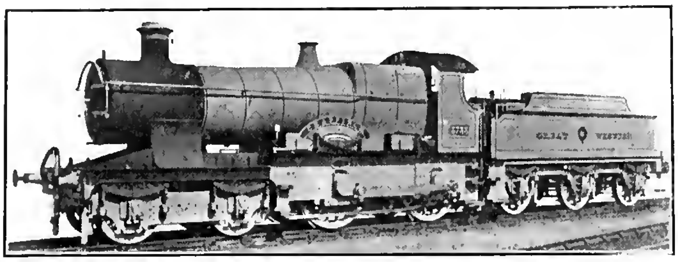
The next aspect of development is exemplified by the "Godolphin," which had the later style of outside frames, domeless boiler with straight barrel and safety valve mounted thereon, Belpaire firebox, and an extended smoke-box supported by a saddle. It will be observed that a jack was carried on running-board near this saddle.


4-4-0 Type Locomotive "Godolphin"

The final form assumed by this class is illustrated by the "Chaffinch," which has a coned boiler barrel. This engine received a temporary light finish for photographic purposes; though the standard color, then as now, was green.

All engines of the "Bulldog" Class now conform, as closely as possible, to the "Chaffinch" which, since the photograph was taken, has been fitted with top-feed. The class is useful on hilly and otherwise difficult sections of the line, and consists of about 135 engines. The dimensions are as follows: Cylinders 18 by 26 inches, drivers 68 inches, boiler pressure 200 lbs., grate area 20.35 square feet, heating surface 1,348.95 square feet, tractive effort 21,060 lbs. The engines have inside cylinders and superheaters.

The evolution illustrated by the three photographs which accompany this article occupied about a decade, and constituted a good investment in the light of subsequent history. When, under the "grouping" system, the Great Western took over an assortment of small lines in its territory, it found that a thorough "house-cleaning" would be needed before these lines could be knocked into the right kind of condition to serve as parts of a high-class railway. This work has been in progress ever since. When completed, a re-assignment of motive power will be possible, by which all through passenger trains over main routes will be handled by 4-6-0 engines of the "King" and "Castle" classes, and considerable numbers of the inside-cylinder 4-4-0 engines will be released for service on these absorbed lines. As the 68-inch 4-4-0 engines are powerful for their size and quick on the get-away, they should prove highly successful in such service. Having received a fair allowance for maintenance since they were built, they are still in good condition.


Locomotive "Chaffinch" of the Great Western Railway of England

A program of improvement on the former Cambrian Railways promises much for the future. These lines serve a number of Welsh resorts, some of which are seaside places, and most of which would attract crowds if the services were good. Here is a case in which the creation of traffic appears possible. At any rate, the G. W. R. is going to try it.

In the course of time, the old motive power on these subsidiary lines will be scrapped, both because of its age and because it does not conform to G. W. R. standards. Clearly enough, it would be cheaper to do this than to carry large stocks of spare parts for odd and obsolete classes of engines.

This carries a lesson for American railroads. Certainly, numbers of engines in service in the United States are decidedly over-ripe! It would cost more to overhaul them than they are worth; so they go limping around, protesting at every revolution of the drivers, and losing more business than they attract.

Appraisal of old locomotives is a fine art, but is attempted very frequently in a perfunctory manner. That is why good engines occasionally hit the scrap-heap, and no-account wrecks are kept in service. Part of the difficulty in America proceeds from the divergence of opinion as to the future of railroads in certain localities, and the consequent leaving to chance the disposition of obsolescent motive power.

I take this opportunity of thanking various correspondents who have been kind enough to express interest in these articles.

In the meantime, it should be explained that the engines of greatest interest are those which illustrate the steps by which the G. W. R. reached its present place in the field of locomotive engineering. Like most other railways, the Great Western "picked up" from time to time, engines which did not represent any particular advance over contemporary practice. As such, these engines are of no special significance today; and, hence, do not call for extended comment.

It has been said that the future is built upon the past. That is true, to some extent; though that part of the past which is "built upon" is usually arrived at by a process of selection and elimination. To realize this, it is necessary only to recall the many valves and valve-gears which failed to deliver the percentage of savings promised by their designers.

Car Shop Efficiency

At the annual meeting of the Railway Car Department Officers' Association held in Chicago a paper was presented by Mr. E. G. Chenoweth, General Car Foreman of the Chicago, Rock Island & Pacific Shops, Chicago, of which the following is a brief abstract:

It is the object of every loyal superintendent of a shop to produce good results, and if the results are maximum under conditions encountered, high efficiency should be conceded. There is often no difference between an O. K. rough freight car, and a very bad order car requiring rebuilding. The policy of the railroad with the judgment of local supervisor, taking in account local condition, decides what should be done, and to err in policy or judgment along this line is often expensive.

In discussing shop operation the outside influences cannot be divorced. The railroad's business is the selling of transportation to the customer, and this is paramount, as equipment is of no value only as it is used for commercial transportation. If the demand of the customer changes quickly, is it not a fact that efficiency then could be measured by the speed that the shop policy can be changed to meet the requirements of transportation? To change from one class of equipment to another as a shop preference at a moment's notice is not unusual. This is to meet the demands for certain classes of equipment, local or otherwise.

One of the problems which is encountered continually in some form or other is the question of material. The shortage of repair material will disrupt an organization quicker than any one other condition.

In the Rock Island shop where I am employed, the number of items of material shortage was decreased one-half by submitting to the stores department each day a statement showing material men reporting all shortages where found.

The procuring of material is, of course, ever essential, but the handling of this material after its arrival at shop is a study in itself, especially in a large shop. There must be a constant flow of castings, lumber, forgings, wheels, etc., from the storage to the consumer, and moreover, it must be delivered in advance of time required. Trained material deliverers are essential to procure good efficiency. They should be kept in one class or on one kind of material where possible to do so, and not changed around.

It was stated above that the man at the car should have the material delivered to him, and this material should be as nearly ready to apply as conditions will allow, steel fabricated ready to apply, and at all sills, plates, carlines, posts and braces, etc., framed in mill; decking, siding, sub-roofing, etc., cut to length before being delivered by a swing saw which can be set up in a shed in lumber yard for this purpose, and need not be handled in the mill. A supply should be kept in stock.

I want to emphasize the importance of properly organizing the forces which deliver material. Proper trucks should be provided and kept in repair for the handling of this material. Where cement or other good roads are installed, of course, the tractor with trailers are considered very modern outlay, but many shops are still equipped with the industrial tracks with turntables or turnouts, and these are very good if properly installed to meet the shop requirements. Where trucks for different commodities are standardized, the checking of loads by the piece work checker is simplified.

In a large repair yard it is advantageous to have bolt rack located in yards which are supplied by different sizes of bolts and perhaps other standard material. Also brake beams and a few pieces siding and decking in racks properly located.

In a great many freight car shops throughout the country repairs are made in the open, and this was considered satisfactory, but today there is a tendency in modern plants to construct buildings or sheds so that the weather conditions to a more or less degree do not control and the painting and stenciling held up. Therefore, building of sheds for painting of cars should first be considered in the modernizing of shop outlays.

The painting of equipment is essential and it is not advisable to wait for a general overhauling in order to paint. Light repaired equipment should be painted as the condition of cars and shop conditions warrant. The spraying of paint is entirely satisfactory. A little brushing is done to take up any runs, and this is done from the ground using large brush with long handles. The average time required to spray one coat on a car is approximately 45 minutes for the first coat and longer for other coats as these require brushing.

To afford increased efficiency there should be included electric welders, gas cutters, rivet busters and a well equipped tool room, equipped with a drill and reamer grinder so that the attendant can use all of this spare time in conditioning drills and reamers. He should also oil and make light repairs to pneumatic tools.

In operation of any plant the safety and welfare of employes should not be overlooked.

There are five items pertaining to shop operation, which appear to me to deserve careful study: Material and handling, arrangement of yard tracks, some method of computing earning based on work accomplished, organization and facilities—shop, tools, etc.

Air Brakes and Foundation Brake Gears for Gas Rail Cars

A Report to the Air Brake Association by the Central Air Brake Club

In order that the importance of this paper may be appreciated, it will be necessary to discuss partially, the many classes of equipment now in service.

It is not our thought that any departure from the present standards will be necessary or that any new or specially designed equipment will be required, but we do know that the many classes now in service work a hardship on many departments of a railroad and is not conducive to the high standard of performance that all railroads wish to maintain.

Gas Rail Motor Cars varied widely in their operating characteristics and when in the process of development and construction it was natural that a great difference was required in the body, framing, truck and equipment details.

There are a number of gas rail brake equipments in service today, having widely different characteristics of operation. A brief discussion of these older brakes is included as a matter of record and interest, for there are a number of these vehicles in service. These brake equipments meet the operating conditions for which the vehicles were constructed.

Some of the earlier cars were designed for operation as a single unit with no provision for trailers. A straight air brake equipment met these operating conditions admirably. Fundamentally this type of equipment consists of a compressor (or other means of furnishing the pressure supply), main reservoirs for storage, governing device for controlling the compressor operation, safety valve for the protection of the main reservoirs, and brake valve for the admission and exhaust of air to and from the brake cylinder. Minor brake and piping accessories such as gages, cut-out cocks, strainers, etc., were included as necessary.

The compressors for these units represented a number of different drive arrangements, and many types of pumps were used. Small single cylinder and two cylinder air cooled compressors were adapted to this class of service by various modifications, some with a direct connection to auxiliary shaft in the engine, some with a gear drive from the power take-off on the transmission, some with belt drive, and some were similarly connected to the main drive shaft.

Similarly the compressor governors, or controlling devices, differed widely—from a manual control by which the operator cut in and cut out the compressor by a gear shifting device, to an automatic governor which started and stopped the compressor between definite pressure limits through the medium of a de-clutching arrangement built in the compressor housing. Some of these compressors were operated continuously (while the engine was running), against a pressure regulator of the safety blow-off type, so that when the pressure reached the desired maximum the regulator would open and allow all excess air to pass directly to atmosphere.

Another interesting form of compressor control was made a feature of the compressor design and known as clearance volume regulation. With this arrangement the clearance volume of each compressor cylinder was so proportioned to the total cylinder volume that the compressor could not raise the pressure above a certain predetermined amount. These pumps run continuously.

Another means of compressor control between the definite predetermined limits was to supply an automatic governor which supplied air to a cut-out cylinder at the maximum pressure and exhausted the air from this cylinder at the minimum pressure. This cut-out cylinder in turn operated small plungers which unseated the suction valves. This is probably the simplest arrangement for the control of mechanically driven compressors to operate between definite pressure limits.

The straight air type of brake valve is fundamentally a three-way cock which in one position admits air to the brake cylinder, and in the second position exhausts air from the brake cylinder. An intermediate position is provided where all ports are blanked, which permits the valve to be lapped. Sometimes accessory application and release positions are provided, which throttled the flow of air to or from the brake cylinder. The detailed construction of these valves is not particularly important, but they are generally based on the rotary valve principle though some poppet type brake valves can also be found in service.

As a rule the brake cylinders were of standard design, though a small size.

This equipment, is, of course, suitable for single car operation only. For the operation of motor trailer units, with trail cars specially designed for the manufacturer's particular motor car a straight air equipment was provided, having an emergency feature to set the brakes in case of a break-in-two.

With this arrangement the emergency valve does not move with the service application. The only difference between service and emergency brake effect is in the time required for a full brake application, the emergency being much the faster.

It is customary to supply a conductor's valve of standard design in each car, which permits the brakeman or conductor to make an emergency application of the brakes.

The trailer car brake equipment is similar to the motor car brake except that the brake valve and main reservoir pipe are omitted, and the main reservoirs are replaced by one supply reservoir. This tank is charged from the emergency pipe through the emergency valve in release position and furnishes an independent local supply of air for the trailer brake cylinder during an emergency application.

It is, therefore, obvious that with a break-in-two application, both emergency valves assume the emergency position and on the motor car admit main reservoir air to the brake cylinder, which is cut off from the straight air pipe, and on the trailer car, admit supply reservoir air to the brake cylinder, which is also cut off from the straight air pipe.

This equipment permits a very flexible control of the service brakes on a motor trailer unit and provides for automatic application in case of break-in-two, without the triple valve complication and maintenance.

Motor cars in service and building, which are designed to handle a standard passenger coach as a trailer, require a combined automatic and straight air brake equipment. Some of these motor cars have sufficient power to handle a number of standard passenger or freight cars on low speed schedule, or in switching service and, therefore, should be equipped with an equalizing piston type of brake valve.

This brake equipment is somewhat similar to the equipment previously described, except that the emergency valve is replaced with a triple valve, which provides for quick recharge, quick service, graduated release and high emergency cylinder pressure. This triple valve requires the application of one auxiliary and one supplementary reservoir per car, and the following items are also used: Feed valve to automatically maintain a predetermined pressure in the brake system, a double check valve which separates the automatic and straight air systems, so that the operation of either may be obtained without interference. It is, of course, necessary to use additional strainers, cut-out cocks, dirt collectors, couplings, etc.

The main reservoir supply admits air through a cut-out cock to the feed valve which in turn supplies the brake valve. The brake pipe is made up to the brake valve and hose connections, through the necessary strainers and cocks to the triple valve and to the conductor's valve. The straight air application and release pipe connects the brake valve to the double check valve, which in turn is connected to auxiliary reservoir, brake cylinder and triple valve. In addition to the brake pipe and the double check valve connection to the triple valve, are the supplementary and auxiliary reservoir pipes. Air for the compressor governor, signal system and for accessory pneumatic devices is taken directly from the main reservoir. The brake valve for this equipment should be of the rotary valve design, and the straight air service and automatic functions should be detailed in the one valve. The valve handle positions beginning at the left of the quadrant should be release, straight air lap, straight air application, automatic lap, automatic service, handle off, and emergency.

Inasmuch as the straight air system will apply the brakes on the motor car only, it should be used only when the vehicle is in single car service. A cut-out cock is provided in the straight air pipe under the brake valve, so that the straight air system may be cut out when operating a train of two or more cars. During single car operation air is admitted at feed valve pressure through the straight air application and release pipe to the double check valve and from there to the brake cylinder to apply the brakes, which may be graduated on or off in any number of stages, under the direct control of the engineer. This is the most reliable flexible brake control, and for that reason is supplied for single car operation.

When operating a train the straight air feature should be cut out and brake pipe reductions and recharges made in the usual manner. It should be noted, however, that it is impossible to overcharge during normal operation, for the feed valve supplies all air to the brake valve, and there is, therefore, no position where main reservoir pressure can be introduced into the brake pipe. The handle off position is required on double end equipments to prevent manipulation of the non-operative brake valve by unauthorized persons, for it may be located in a position partially exposed to passengers. The emergency position of the brake valve performs the functions with which you are all familiar; namely, to create a rapid reduction in brake pipe pressure, and in addition also to charge the straight air by-pass pipe. If for any reason the triple valve or valves fail to apply, a straight air application will be secured on the motor car, for the by-pass pipe is connected to the straight air pipe at a point below the straight air cut-out cock. This is also a non-return check valve with an orifice, through the valve itself in the straight air by-pass pipe, which reduces the rate of straight air application in emergency, so that the triple valve can still vent brake pipe to brake cylinder, and also freely permits straight air release.

The double check valve has several important functions; first, to permit either a straight air or an automatic application without interference from the non-operative brake system; i. e., to deliver air to the brake cylinder from either one of two sources and seal off the unused source against blow down and leakage; second, to permit the complete release of brake cylinder air when the brake valve is placed in release position and the brake pipe recharged; third, to prevent stuck brakes in case a partial straight air application is made followed by an automatic application. Inasmuch as this double check valve is a new device to most of our members, a detailed description here might not be out of place. It consists primarily of a floating piston valve, one end of which is connected to the normal triple valve brake cylinder pipe tap, the center to the brake cylinder, and the other side of which is connected to the center of a relay piston, so that when a straight air application is made the relay piston unseats an auxiliary reservoir valve, allowing this pressure as well as the straight air pressure to flow directly to the straight air side of the floating piston. With either a straight air or an automatic application, therefore, the floating piston seals off the non-operative systems and passes the application air directly to the brake cylinder. The purpose in unseating the auxiliary reservoir valve with a straight air application is to insure a reduction in auxiliary reservoir pressure, which will not only hold the triple valve in release position even though there is excessive brake pipe leakage or a depletion of main reservoir pressure, but will also insure an auxiliary reservoir reduction sufficient to permit the return of the triple valve piston to release position if an automatic service application is attempted following a partial straight air application.

Where trailer cars are supplied with these motor cars they should be equipped with a standard passenger car brake arrangement and include a triple valve having functions identical with that on a motor car. Hose connections, couplings and angle cocks should be supplied with these units in accordance with steam road standards.

There are about four different types of compressors and compressor control units which have proven fairly satisfactory in service and which are being installed on the majority of all cars under construction at the present time.

With the gas electric vehicles it is, of course, apparent that a motor driven compressor with a pneumatically operated switch, which will cut the pump in and out between definite specified pressures, is ideal.

With the gas rail cars where there is no major source of electric power supplied the compressor must be mechanically driven. These mechanically driven compressors may be controlled in either one of two ways: Either by declutching the compressor when the maximum pressure has been attained and then resuming operation when the minimum pressure is reached through the medium of a pneumatic governor, or by unseating the suction valves with a similar control device working on a definite range. While these two systems of compressor control have their advantages as well as disadvantages, it is hardly the purpose of this paper to discuss this in detail, for they have both proven quite satisfactory in service.

The fourth method of compressor arrangement will be found on recently constructed cars where it was disirable to use a high speed, air cooled, two cylinder compressor with mechanically controlled suction valves. This suction valve arrangement is fundamental to a successful high speed compressor, for the limit of speed of compressor operation with automatic suction valves is dependent upon the effective speed of the valve opening and seating. With this type of compressor an arrangement has been developed so that the governor instead of supplying air to unseat the suction valve, in effect unseats auxiliary valves in the compressor head, which when opened connect the cylinders together with the result that there is no net piston displacement for the combined unit. No air is, therefore, supplied by the compressor when the governor cuts out.

It would seem that no discussion of any new brake equipment is complete without a very thorough consideration of the brake ratios used, and the leverage system adopted. "For the benefit of those who have not made a study of this phase the following explanation is offered: Brake ratio is the quotient expressed in per cent of the nominal total brake shoe force divided by the car weight. The nominal total brake shoe force is, of course, basic unit cylinder pressure multiplied by the brake cylinder piston area, which, in turn, is multiplied by the total leverage ratio." There are so many different uncontrollable variables in the details of car and track construction and operating conditions which effect the brake performance that brake ratios are determined empirically. For new cars it becomes necessary, therefore, to compare the vehicle under construction with some of those already in satisfactory service and to make suitable corrections for their different operation or construction characteristics. As a matter of fact, so much elaborate data has been secured on the different factors controlling brake operation by actual tests in the field under widely varying conditions, that it is possible through a proper understanding of the limitations of this data to predetermine brake ratios successfully.

The present gas rail and gas electric motor cars are very closely similar in their details of construction and operation to standard traction or electric railway units in service today. The gas electric truck is a traction truck, and although in the gas rail truck the motors are replaced by the differential and drive shaft, the fundamental controlling factors actually put this truck in the traction class, especially the power truck. For these reasons, these cars have been braked in accordance with traction standards: that is 100 per cent brake ratio based on 50 pounds cylinder pressure.

Motor car trains with a standard passenger coach as trailer will, therefore, have a more effective brake on the motor car than on the trailer, in the ratio of 100 to 75 for a full service application. The slack action in a two-car train under these conditions was thought would not be noticeable, and the tendency would be to keep the slack in during a brake operation. One reason for using a higher ratio for these units than the steam road passenger ratio of 90 per cent on 60 pounds is that considerably shorter stops could be secured with a higher ratio, with which there is greater protection against wheel sliding than on standard passenger cars, for the brake control is much more flexible. Due to the fact that feed valve pressure is available with a straight air application, restricted slightly, however, by the spring in the double check valve, the full straight air service brake ratio is 135 per cent approximately. The high emergency feature of the triple valve also provides for 135 per cent approximate brake ratio in emergency.

The short wheel base of these trucks requires the use of the single shoe type of brake rigging, and on account of the installation of drive shaft and differential on the gas rail trucks and the motor on the gas electric trucks, the truck levers should be located between the wheel treads and connected to the pull rod through the medium of an equalizer bar. Because the shoes must be considerably below the wheel centers to prevent journal displacement and tilting, and to allow for rail clearance of the bottom rod, truck ratios should be comparatively high, and the total possible travel of the live truck lever is limited so that on most trucks that is the primary point of brake rigging fouling with excessive shoe wear. With these limitations, therefore, it is obvious that a brake rigging with a nominal initial brake cylinder piston travel of approximately 5" will permit of a greater linear shoe wear than a similar rigging with 8" initial travel; i.e., with 5" initial piston travel the car can make greater mileage between bottom rod slack adjustment take-up periods than with 8" initial piston travel.

For these reasons the traction standard of 5" nominal piston travel should be adopted for these equipments and auxiliary and supplementary reservoirs should be accordingly reduced in size so that full equalization only will be obtained with a 20-pound reduction off of 70-pound brake pipe with the brake cylinder travel at 5". Gas rail and gas electric brake equipments should, therefore, have auxiliary and supplementary reservoirs of smaller size than has previously been standard for steam road service where the piston travel has been based on 8".

Recommended practice for the total maximum leverage ratio on steam road passenger cars varies from 9 to 1 with 8″ and 10″ equipment to 5½ to 1 with the double 18″. Traction car recommendation, however, permit the use of a 12 to 1 total leverage ratio, though 10 to 1 is acceptable as a maximum where it is feasible for the particular car design under consideration. Account of the traction characteristics of these trucks, the recommendations are for the traction standards, i. e., with a maximum total leverage ratio of 12 to 1. This recommendation is logical and based on engineering requirements.

With any car having this type truck, with a fixed truck ratio, where the travel of the top of the live lever is the limit of the brake effectiveness, it is obvious that the total leverage ratio of 12 to 1 will not permit as great a car mileage between bottom rod slack adjustment periods as would a lower total leverage ratio. In explanation we might add that with a fixed truck ratio, the higher the total leverage ratio, the higher will be the cylinder leverage ratio, therefore, with 5″ initial piston travel the high cylinder leverage ratio will provide greater remaining live lever travel available for shoe wear.

The brake rigging for these gas rail and gas electric cars should be designed in accordance with the ARA stress limitations which are briefly as follows for wrought iron and mild steel:

> Maximum recommended stress for pins in double shear, 10,000 pounds per sq. in. Maximum recommended stress for struts or compression rods, 15,000 pounds per sq. in. Maximum recommended bending stress in levers and beams 25,000 pounds per sq. in. Maximum recommended stress in rods in tension, 15,000 pounds per sq. in.

When it is found desirable to use high carbon or alloy steel for the foundation brake details, higher maximum stresses are, of course, permissible.

It is recommended to adjust brake shoes with ⅛″ clearance.

Brakes will be set with a movement of from 2 to 2½″ at the top of the live lever, giving a 4 to 5″ piston travel. Total travel of the live lever is ordinarily limited to 5″, which gives from ½ to ¾″ shoe wear. The live levers should be connected at the upper end with an equalizing bar, which insures even pressure being applied to each side of the truck.

In order to reduce weight, advantage should be taken of the increased strength and stiffness of this steel, so that brake beams, equalizers and levers can be figured with a 23,000-pound fibre stress with service application of brakes. With emergency application the fibre stress will, of course, be increased. In comparing this practice with standard A. R. A. practice, using ordinary steels of from 55,000 to 60,000, tensile and elastic limits from 27,000 to 30,000 pounds per square inch, being worked at a fibre stress of 23,000 pounds, as compared with a steel having an elastic limit of 40,000 pounds, with ordinary working load of 23,000 pounds fibre stress, and in an emergency application of 135 per cent of the normal, the fibre stress would be 31,000 pounds.

It is readily seen by comparison that the maximum fibre stress is proportionately the same in these standard materials.

23000 : 30000
31000 : 40000

In case of accident, it will hardly be necessary to replace the brake parts from standard stock, as their position in the truck almost precludes their being damaged. If they should become distorted, it will only be necessary to reshape them and after the forging operation is completed bring them to a dull cherry heat and allow them to cool slowly in a furnace.

As to the necessity of replacing them on account of wear, all the holes should be fitted with case hardened bushings and the pins should be case hardened. It would, therefore, only be necessary to replace worn bushings, as the life of the parts would be indefinite.

The entire equipment, body, trucks, brakes, etc., should be laid out to give the maximum strength for the weights allowed for this class of car.

Trucks and car bodies should be so designed as to permit full piston travel without interference of any of the parts and permit the use of total lever ratio as recommended for standard steam road passenger cars.

Where compressors of the electric drive type are used they should be controlled by a pneumatic device that will control them within a definite range of not to exceed 10 pounds variation.

Mechanical driven compressors should be equipped with a pneumatically-operated device restricting further compression when the maximum pressure is obtained.

Compressors of the following capacity are recommended:

For the motor unit not less than 16 cubic feet per minute and an additional 10 cubic feet for each trailer anticipated.

All compressors should be equipped with a device between the strainer and compressor to prevent freezing.

Main reservoir capacity to be not less than 10,800 cu. in. for 10″ cylinder, and when additional reservoir capacity is desirable, two or more reservoirs should be used, and the additional reservoirs should be separated from the first by a "parasite" governor.

Main reservoirs must be equipped with a safety valve that will open at not to exceed 10 pounds above working pressure.

All piping of motor cars to be of wrought iron or copper.

All brake valves to be of the rotary type with an equalizing piston. Straight air and automatic features integral.

A feed valve located in the main reservoir supply pipe between the main reservoir and brake valve at a point convenient to the engineer. This to reduce main reservoir pressure to that of brake pipe.

Gages located at a point convenient to the engineer from his usual position in the cab, indicating main reservoir, equalizing reservoir, brake pipe and brake cylinder pressures. A feed valve and non-return check to be located in the straight air pipe below the brake valve and above the straight air cut-out cock, so that the straight air pressure may be reduced to a nominal force when used.

A cut-out cock to be located in the brake pipe below the brake valve at a point convenient to the engineer. This to be closed when the car is being handled dead in a train.

A double check valve as previously mentioned, known as the No. 14 double check, to be located at a point convenient for inspection and repairs, between the brake valve, triple valve, auxiliary reservoir and the brake cylinder.

Where double end control is desired duplicate equipment should be supplied for each end of the car and the straight air pipes should be equipped with a double throw check valve at their junction with the pipe leading to the No. 14 check valve.

The triple valve should be of the quick service, quick recharge high emergency cylinder pressure and graduated release type, with a supplementary and auxiliary reservoir of proper size to produce a braking ratio of 80 per cent on 50 pounds cylinder pressure.

To safeguard against total loss of brakes in case of top or truck rod failure on either end of the car, it would be our recommendation that cars of this type be fitted with two brake cylinders braking each truck independently. The hand brake to work on both trucks and in harmony with the power brakes.

Railway and Locomotive Engineering

A Practical Journal of Motive Power,
Rolling Stock and Appliances

Published Monthly by
ANGUS SINCLAIR COMPANY
136 Liberty Street, New York
Chicago Office: 168 North Michigan Avenue
Telephone Rector 0746. Cable Address "Locong." N. Y.

Harry A. Kenney, Prest. and Man. Ed.
W. E. Symons, Associate Editor
J. Snowden Bell, Associate Editor
Thomas P. Kenney, Secretary

LONDON REPRESENTATIVE
The Locomotive Publishing Company, Ltd., 3 Amen Corner, Paternoster Row, London, E. C., England.

SUBSCRIPTION PRICE

$2.00 *per year,* $1.00 *for six months, postage paid in the United States, Canada and Mexico. For other parts of the world,* $2.50. *Single copies,* 20 *cents. Remit by Express Money Order, Draft, Post Office Order or Registered Letter.*

Mailing address can be changed as often as necessary—always give old and new address, and if you subscribe in a club, state the name of the agent.

Please give prompt notice when your paper fails to reach you regularly.

Entered as second-class matter January 15, 1902, at the post office at New York, New York, under the Act of March 3, 1879.

Railway Tax Burdens

Railway taxes are now running at the rate of one million one hundred thousand dollars a day. These taxes come out of railway revenues, and revenues come from railway rates. The public pays railway rates and, therefore, railway taxes.

Taxes are necessary to operate city, county, state and national governments and the justification of levying reasonable taxes on railways is not disputed, but 1926 was the sixth year since 1919 in which taxes exceeded railway dividends. More than three-fourths of all the taxes are levied by state and local governments. Railway taxes have increased 228 per cent in the last thirteen years, while dividends in that time have increased only 22 per cent.

The carriers are placed in the dangerous position of being compelled to pay from year to year enormous increases in taxes on improvements made to provide adequate service, while, at the same time the return which the carriers are permitted to earn on the capital so invested has at no time reached the fair return to which the Transportation Act, 1920, held they were entitled.

Railways are confronted with the fact that many of the improvements they make for the benefit or convenience of the public such as the elimination of grade crossings, new passenger stations and similar additions to their property, neither bring them additional revenues nor serve to reduce their expenses, but become objects upon which they must pay additional taxes. In the case of grade crossings, for example, the railways not only have to pay a large part of the cost of eliminating the crossings, but the resulting new bridge frequently becomes an object of new taxation.

Local taxation is levied on the real property of the railway. These same taxes also fall on the farmer and his land and buildings; on the merchant and his store; on the manufacturer and his plant; on the home owner and his home; and on the tenant whose rent must include the taxes paid by his landlord.

A return to more economical standards of public expenditure by our local governments would help bring down the cost of living for everybody.

The situation demands the help of every citizen, whose duty it is to see that the taxes he pays are wisely expended, and with the same system and economy which should characterize any business enterprise.

The Metric System

In the September issue of this publication there appeared an article dealing with the Metric system of weights and measures and the propaganda of the advocates of the system for further action by Congress in the fourth-coming session which is wide-spread. If we may judge by the rather complimentary and generous response which the article referred to brought from correspondents in all sections of the country, we at once realize that the present English units in use in the United States is an integral part of American institutions.

The American Railway Association through its various agencies is combating the effort now being made to influence further legislation looking to the general and perhaps compulsory adoption of the Metric system.

That the railway or transportation industry may not be underestimated by those who are interested or might be affected by this proposed change, a statistical display embracing a general statement and details of certain items is here presented for information and study. A rather comprehensive statistical picture of class one (1) railways, which represent about 95 per cent of the mileage, investment or value, and handle about 98 per cent of the transportation business of this country is about as follows:

Estimated value about	$25,000,000,000
Track or line mileage	249,421
Total all tracks	412,361
Average number employes	1 333,398
Total compensation	$3,027,997,000
Total revenue from operation	$6,506,163,269
Total expenses taxes, etc.	$5,232,702,775
Estimated value of equipment, about	$7,152,154,800
Annual expense to maintain	$1,301,739,775
Passengers carried one mile	335,536,073,612
Tons freight carried one mile	444,500,146,373
Number of trains run per year	15,000,000
Number of trains run per day	41,000
Amount taxes paid (1926)	$398,376,738
Per cent earnings	6.12

From the foregoing there can be no question as to the great importance of the railways in the matter of invested capital, number of employes income from operation, disbursement of funds for material, wages and taxes, the latter item having reached almost $400,000,000 per year.

There are about 33,000,000 male persons, and about 8,500,000 females, 10 years of age and over, a total of about 41,600,000 persons gainfully occupied in the United States and among this great army that really produce the wealth of this nation, there is not a single industry more vitally interested in this question of the standard units of weights and measures than the railway officers and employees. Many of them have spoken and others will be heard from both collectively and individually.

One of the reasons our railways have reached their present high standard of efficiency is that in location construction, operation, and maintenance they have had and now have as an essential part of their working tools or equipment, a most suitable and satisfactory standard of units of weights and measures with which to do business.

To attempt to destroy the present standrard units, and substitute the metric system on our railways alone, would result in great expense, endless confusion, lowered efficiency of service, and ultimate failure of the plan.

It should be interesting to know the character and standing of those who defend our English units and oppose the metric system. From a recent compilation we quote the following:

The Council of the American Institute of Weights and Measures which was organized to oppose the adoption of the metric system, contains three past-presidents of the American Society of Mechanical Engineers, a past-president of the American Manufacturers Export Association, a president of the Minning and Metallurgical Society of America, the president of the National Association of Manufacturers and a past-president of the same organization, two past-presidents of the Society of Automotive Engineers, a past-president of the National Metal Trades Association, a past-president of the Society of Naval Architects and Marine Engineers, the president of the Westinghouse Electric and Manufacturing Company, the president of the Stevens Institute of Technology and the professor of Technical Engineering at Yale Universary.

In opposition to the English standard units of weights and measures, is the American Metric Association which was organized for, and is now engaged in an effort to promote the compulsory adoption of the Metric system.

The Council of this Association contains a wholesale druggist, two wholesale grocers, a professor of pharmacy, a director of a museum, a secretary of a bourse and an expert in precious stones.

To which of these bodies should be left a vital question, one in fact that involves the industrial policy of this country, and the happiness and prosperity of the people?

To all intelligent, well informed and fair minded persons there is only one answer.

That those of the sponsors of this Metric propaganda, who are fair minded and sincere, are sadly lacking in correct information on the subject, is clearly brought out in testimony at the hearing, in support of which we quote the statements of two college graduates who are now captains of industry.

The first one who is now in the engineering department of one of our largest trunk railways very tersely says:

"When I came out of college I was an enthusiast for the Metric system, but when I got out in the field among the boys who wear overalls in practical engineering work, I very quickly changed my mind."

The second who was in the U. S. Ordnance Department during the war and is now in the manufacturing business after pointing out the fallacies of pro-metric propaganda has this to say in closing:

"When I came from school, I was very strongly Metric, because it seemed to me a system built up with something behind it, at least that is what the teachers told us, that the Metric was arrived at by calculation of one ten millioneth part of distance from the equator to the pole, and nobody ever stopped to think about how you were ever going to measure it. The joke of it all was that after they figured it all out they found it was not correct, that they made a mistake, so that we have not even the sentimental part of it left."

In some of our well intentioned but sadly misguided friends, who are so strong for the Metric system, will heed the council and advice of those who have had actual experience in its practical every day use they will not only change their minds but their attitude.

Going back to the "Good Book," we find in Deuteronomy, 25-5, the following is the Law of Moses:

"A perfect and just weight shalt thou have; A perfect and just measure shalt thou have; that thy days may be long in the land of Jehovah thy God giveth thee."

Again, about 500 years later in the history of man, we find the following from King Solomon:

"A false balance is an abomination to the Lord; but a just weight is his delight."

Various other quotations could be offered both from Holy writ and profane history, as to laws, customs and practices, with respect to just and fair weights and measures, and the penalties to be enforced against those for violations, but the foregoing, however, seem ample for the purpose.

Those who favor the retention of our English units of weights and measures, are not attacking the Metric system, but quite the reverse, they are defending against attack institutions that are not only sacred but essential to our continued prosperity and happiness as individuals and a nation.

The Metric system has been legalized for more than 60 years, yet by the acid test of practical application has made practically no progress for the simple, plain, common sense reason that it is not anywhere near as well suited for use by English speaking people as the standard units we now have.

If our servants in Congress were ever so unwise as to pass a law making the Metric system compulsory, particularly in view of the negative action of their constituencies it is certain that the law would not be obeyed, but that a lot of politicians would be sent into retirement.

A new kind of crime would have been created, but no government, and no courts of justice could compel a free people to discard a system of weights and measures that was eminently satisfactory, and adopt one to which they were unaccustomed and did not want:

Regulation of weights and measures by law is absolutely essential but to attempt to revolutionize them against the will of the masses is not the work of statesmen whose first duty should be to know what the people don't want and have some idea of what they do want.

Transportation Act Held Successful

In an address before the Illinois Chamber of Commerce at Chicago last week, Daniel Willard, President, Baltimore & Ohio Railroad, discussed certain aspects of the transportation situation as follows:

"I am confident that under the terms of the Transportation Act of 1920 it is possible to so regulate the railroads that the public will receive adequate transportation at reasonable rates as the law requires, and at the same time enable the carriers so regulated to build up and establish a basis of credit sufficient to justify and encourage investors to advance the large amount of new capital required each year for additional equipment, extensions and betterments.

"While no one would claim that the Transportation Act of 1920 is perfect, nevertheless, in my opinion, it contains the best general plan for the regulation of railroads that has so far been tried in this country. . . .

"Investors have shown their willingness to purchase railway securities under existing conditions, but any change in the law would disturb, at least temporarily, the confidence of investors."

Publishers and Contributor Friends

It not infrequently happens in the course of human activities that great reputations or fortunes are built on what are, at times, apparent failures. This is particularly true in the field of journalism, no matter what particular branch or phase may be involved.

In the field of railway literature, the very generous attitude of numerous contributors makes it possible for the publishers to favor their readers with a much wider range of thought on the great variety of subjects treated than would otherwise be possible. The contributions, which for lack of space or otherwise, we can not give space in our columns, is sometimes the source of as keen disappointment or regret to us as to the authors.

The theme prompts us to say to those whom we might appear unappreciative of tendered contributions, that our own is almost like the very generous attitude of certain Chinese publishers in their declination of proffered manuscripts. Some of our American publishers should emulate the example of our Oriental friends, to the authors of rejected manuscripts so that they would, at least, feel that they were still "among friends" anyway.

A Detroit, Michigan, author while in London, England, received the following rejection slip from a firm of Chinese publishers:

"We read your manuscrip with boundless delight, and by the sacred ashes of our ancestors, we swear that we never dipped into a book of such overwhelming mastery. If we were to publish this book it would be impossible in the future for us to issue any book of a lower standard.

"As it is unthinkable that within the next ten thousand years we shall find its equal, we are, to our great regret, compelled to return this divine work and beg you a thousand times to forgive our action."

We not only hope the foregoing may serve as a gentle reminder to busy American publishers, who may appear and sometimes are somewhat unappreciative or harsh in tone with their rejection silps, but as a consolation to the great army of authors whose manuscripts are not used, and the further suggestion that our oriental friends evidently have the faculty of giving a consolation prize more sentimental value than our American masters of the English language could convey to a "prize winner."

Radio in Railway Operation

Admiral Bullard, chairman of the Radio Commission has told the telegraph and telephone section of the American Railway Association that the use of radio in the operation of trains was a perfectly feasible proposition and should be developed, and also of the desirability of control and communication between moving trains and different parts of the same train, as between the locomotive and the caboose.

"Twelve years ago," said Admiral Bullard, "I was approached by one of the larger Western railroads and asked to develop a scheme by which radio could be developed for the control of trains. They had the idea of controlling their dispatching and communication between long freight trains by means of radio.

"I gave a report at the time that it was an impractical proposition and recommended strongly against it. Now, however, the proposition is feasible.

"It must be remembered, however, that every time one of these little waves goes out it fills up and clutters the air. If we had all the railroads operating what we call mobile stations the whole atmosphere would be jammed full of these wave lengths, and it would be an extremely difficult proposition for the Radio Commission to keep them all separated. So I would give a word of warning that possibly you might use some other means."

Admiral Bullard stated that sixteen railroads had for their own use 158,964 miles of telegraph wire. Similarly, these railroads use over 335,000 miles of telephone wire.

He also stated that the use of wireless for communicating between the locomotive and caboose of a train would require a different wave length for every railway, but that he would like to see experiments carried out along that line with all the railroads cooperating.

New Railway Efficiency Records

Striking gains in transportation efficiency for the first eight months this year, as compared with the corresponding period for each individual year since 1920, are reported by the Bureau of Statistics of the Interstate Commerce Commission.

The Bureau's compilation shows improved records for operating efficiency established by the Class I railroads in the following eight out of ten items selected as measures of operating efficiency:

The freight density of the Class I railroads in the first eight months this year, according to the compilation, was 5,467 net ton-miles per mile of road per day.

The gross trainload, 1,772 tons (excluding the weight of the locomotive), and the net trainload, 778 tons (excluding the weight of cars), also exceeded the averages for the other individual years since 1920.

The average gross ton-miles per train-hour in the first eight months of 1927 was 21,768, and the average net ton-miles per car-day, including unserviceable cars, was 515.

The average car-miles per car-day stodd at 30. In computing the average movement per day, account is taken of all freight cars in service, including cars in transit, cars in process of being loaded and unloaded, cars undergoing and awaiting repairs and also cars on side tracks for which no load is immediately available.

The cars per train (including caboose), averaged 46.3. The average pounds of coal per 1,000 gross ton-miles was 130, including the locomotive.

Decrease at Two Points

The two items in which the 1927 performance did not set a record during the period under consideration, according to the Interstate Commerce Commission, are the average carload and the percentage of loaded cars of the total transported. In both of these instances the best performance is shown for the eight-month period of 1920. In that year the average carload was 28.8 tons as against 27.3 tons this year; while the percentage of loaded cars was 69.9 in 1920 as compared with 63 in 1927.

Efficient management has increased net earnings in spite of a rate structure which has resulted in a 2½ billion dollar shortage of actual earnings under the "fair return" on property investment for the past seven years. The "fair return" was fixed by the Interstate Commerce Commission under the provisions of the Transportation Act at 6 per cent until March 1, 1922, and at 5¾ per cent after March 1, 1922. It is based on the carriers' book investment in road and equipment, including materials and supplies and cash, at the beginning of each year.

Efficient management has improved freight service to such a degree that hand-to-mouth buying was made possible, and large reductions of commercial inventories were effected. While the extent of such an influence cannot be definitely measured, it is generally agreed that the actual money value of good transportation is enormous.

Electrification Record in the St. Clair Tunnel

By Walter D. Hall, Supt., St. Clair Tunnel, Canadian National Railways

In September, 1891, 100-ton steam locomotives commenced operation through the St. Clair Tunnel. These could handle a maximum of about 750 tons up the 2 per cent grades but frequently died before reaching the summit so that considerable time was lost in that way and on account of stopping for fire cleaning, coal and water.

Business continued to increase and dioxide and monoxide gases made conditions dangerous, so in 1903 serious consideration was given to the subject of electrification. An inspection of the Baltimore & Ohio electrification through the Mount Royal Tunnel at Baltimore was made as well as a study of tunnel ventilation by means of air traveling at much higher velocities than we had used; electrification appeared to be the one solution to all our problems.

In 1908 we inaugurated single phase electrical operation employing six 67½ ton Westinghouse-Baldwin electric locomotives in which No. 137 railway motors are employed.

In 1908 these locomotives made 154,392 miles, hauled 288,516 cars and about 9,231,500 tons.

Last year, 1926, these same locomotives made 248,025 miles, hauled 468,760 cars and about 19,696,708 tons.

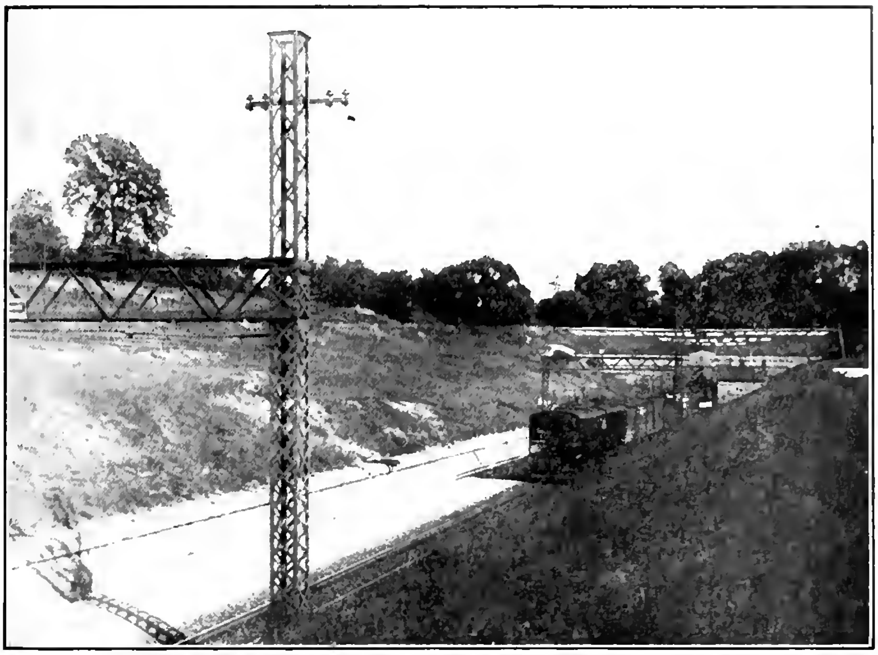
It is 19 years since these locomotives were first operated through the tunnel; during that time they hauled 6,617,590 cars, 268,917,150 tons, and made about 3,934,010 miles, an average of 655,660 miles per locomotive; during all these years there is not a total of one hour's delay charged to locomotive failures and in their 19th year, 1926, they were available for service 97.7 per cent of the time; time not available being made up as follows:

Changing wheels, mostly due to soft tires...	.57%
Electrical, changing armatures, etc........	.57%
Mechanical, equalizers, brake rigging, pinions, etc.	.33%
Hydrostatic and hammer tests and other tests for Government reports	.63%
Derailment damage	.20%
Total	2.3%

The average cost of maintenance per locomotive mile, over this period of 19 years, was 9.45c. Last year, 1926, this cost was 6.21c. per locomotive mile, cost per car mile .659c. and the cost per ton mile .015c.

Our single phase line voltage is 3,300, and the locomotive auto-transformers have been rewound once and the commutators of the traction motors were renewed once. The fields of all motors have given practically no trouble. Five air compressor armatures have been repaired but we had practically no trouble with the blower motor armatures. Controllers and wiring have given very little trouble, requiring only proper inspection and care.

Three or four preventive coils have failed and practically all the union joints in copper rods from these gave trouble at some time, apparently due to the pieces of fine copper gauze used in them; the gauze perishes and leaves a loose joint.



Electric Locomotive Emerging from the St. Clair Tunnel

The pinions and gears have done remarkably well, considering that the drive is from one end of the armature shaft and that these locomotives are in terminal and not in main line service. Some pinions have exceeded 200,000 miles when removed. Some of the original gears are still in service, having made about 655,000 miles.

Records such as these, extending over a period of nineteen years are really worth while, they tell a story of not only the quality of the materials used but also of the designing and judgment of the engineers. These engineers can well feel proud of their achievements in the early days of heavy electric traction.

There is another thing about these locomotives which may be of interest. No trucks are used, the frames are rigid from end to end so that on account of the many curves encountered in the terminal yards, mileage was very low; on account of sharp flanges we tried out oil and hard grease applied in variouus forms but without success.

In 1910, our yard engine tires were making about 42,000 miles between turnings, we were making a maximum of about 25,000 miles, which meant a lot of time lost over the pit as well as a big expense.

A flange lubricator was applied, similar in principle to an atomizer, so that the engineers could spray oil onto the wheel flanges, when approaching curves, by pressing a contact button at any of the controllers. This scheme was so satisfactory that some of these tires made more than 150,000 miles between turnings and a total of more than 300,000 miles.

The bearings of these locomotives have given practically no trouble.

Overhead Lines

Some interesting things turned up in connection with insulation of the overhead lines.

Strain insulators began to blow up during wet weather and it was found that due to a slight movement having taken place in the insulator or perhaps due to expansion, the ends had cracked and soot and acid from steam locomotive gases was washed into these cracks during rain storms; we overcame this difficulty temporarily by making shields of sheet fiber which we wrapped around the insulators, allowing the shield to extend beyond the ends about 8 inches.

As opportunity presented we installed other insulators which gave splendid service but even with these we experienced some difficulty when hauling heavy ore trains beneath them with steam locomotives; the exhaust gases and moisture would short circuit insulators and result in a short to the bridge structure; this trouble we overcame by placing two insulators in series a sufficient distance apart to prevent gases emitted from the locomotive stacks striking both insulators at the same time.

In the tunnel were 480 insulating devices which supported two parallel trolley wires from two parallel messenger cables, the insulating medium was about 6 inches of impregnated wood. The two messenger cables were supported on "barrel type" porcelain insulators. Apparently, due to unequal expansion and contraction, the barrel type insulator would sometimes crack and during damp weather, the 480 wood insulators allowed sufficient leakage to blow up the line.

An average of eleven short circuits per year resulted from this cause and was liable to happen any time during the night or day.

The wood insulating devices were assembled with hexagon headed bolts and hexagon nuts and were very difficult to get at even with a box wrench and thus a lot of time was lost in getting them clear of the line.

To overcome this difficulty we made 480 insulating supports of ⅛ inch x 1 inch strap iron and standard 10,000 volt pin type insulators. This was in 1915 and since that time we have not had a single failure, although the barrel type insulators continue to crack, sometimes sections even break away and fall to the floor of the tunnel. In this device bolts square under head and square nuts are used so that they can be easily and quickly removed from the line.

By this time any of you engineers who are particularly interested in power plant construction and operation will be wondering how that end of the installation behaved.

Power Plant

Our plant consists of two Westinghouse, 3 phase, 25 cycle, 3,300 volt turbo-generators, two barometric condensers, two engine driven exciters, one motor driven exciter and two air pumps on the main floor.

In the turbine room basement are two engine driven circulating pumps of the centrifugal type (capacity 5,000,000 gallons each in 24 hours), one house pump and two engine driven stoker fans.

The boiler room contains four B. & W. water tube boilers equipped with underfeed stokers, an independently fired superheater, two feed water pumps and overhead gravity feed coal bunkers.

The turbines gave very good satisfaction during the 14 years the plant was in continuous operation and they still give good results when we are required to operate the plant, due to a failure of the power company.

The stators of our turbo-generators did not give any trouble but after about six years we had the fields rebuilt on account of indications of insulation failure.

During a severe electrical storm, some years ago, the stator at 3,300 volt end of the main exciter burst into flame. We extinguished the fire, changed to a steam exciter, cut out the damaged coils and put the main exciter back into service until repairs could be made; this was done without interruption to service because the motor operated on one phase while we were changing to the steam exciter.

The water tube boilers and stokers gave excellent results, especially when it is considered how erratic the load conditions are. During the entire 19 years, very few boiler tubes were renewed, although the three boilers with a combined rating of only 1,200 H.P. were called upon to deliver 3,000 H.P. at frequent intervals.

The steam driven auxiliaries gave very good results but the cost of maintenance of reciprocating boiler feed pumps, largely due to cost of labor and material for packing, is much greater than that cost for the centrifugal pumps.

This steam-electric plant operated continuously for fourteen years with the responsibility of handling a large and important volume of business between Halifax and other points of our railroad in the east and our Chicago terminal in the west, and during these years there is only 15 minutes charged against the plant on account of avoidable delay.

Oil-Electric Cars on the Chicago & Northwestern Railway

What is commonly known as the State Street and North Pier yard of the Chicago and Northwestern Railway Company is a section of great congestion. A 2-track line extends for a distance of 1¾ miles along a street that parallels the nearby Chicago River. Its northern terminus is at the Pugh Warehouse on the North Pier, Lake Michigan. At frequent intervals along the course of the yard, warehouses, manufacturing establishments, and other industrial and mercantile structures rise at the sides of the tracks. An almost continuous line of them exists on one side. Among them are buildings housing concerns of importance in the business world, such as Hibbard, Spencer & Bartlett; Reid, Murdoch and Company; the Chicago Tribune, and others.

Oil Electric Locomotive in Use on the Chicago & Northwestern Railway

At various points, one or more tracks branch out from the 2-track system to serve these establishments. In places a veritable maze of trackage exists. The system crosses numerous busy streets, including Michigan Avenue. The general traffic of these thoroughfares is carried overhead, but entryways are provided at the track level to permit trucks and teams access to cars and to the buildings fronting the tracks. The switching of cars within such a zone is fraught with difficulties. Because of the crossings and the traffic in the street, itself, a constant watch must be kept to avoid accidents.

After making a study of the situation, the Chicago and

Northwestern officials determined to try out some other form of locomotive than the familiar steam type and, in May, 1926, a 6-ton oil-electric locomotive began operations. Improved conditions were so immediately evident that another unit was placed in service in October, 1926; and in April, 1927, a third was added. This type of locomotive now handles all the switching in the State Street and North Pier yard.

The substitution of oil-electrics for steam motive power units has effected a saving in operating costs, according to L. P. Michael, mechanical engineer of the road. Specific figures of comparison are not yet available because insufficient time has elapsed to arrive at the maintenance costs on the new locomotives.

Some of the savings and advantages of the oil electrics were outlined as follows by George Hand, assistant to the president of the Chicago and Northwestern Railway Company:

"We found in our investigations that the locomotives in this service were running only 40 per cent of the time and were accordingly standing idle the remaining 60 per cent. With steam locomotives in use, steam had to be maintained all the time and coal was being burned when the engine was motionless. In the case of the oil-electrics, the oil engine idles when power is not being used and the cost of fuel consumed is negligible.

"The steam locomotives worked two shifts of 12 hours each. After each shift they were taken 4 miles to a roundhouse. The oil-electrics are in service the full 24 hours, the 3 new units having replaced 6 steam units. This has resulted in the elimination of some roundhouse charges and also of some shop service and hostling charges. There has also been a small saving in wages paid engineers. The wage contract is based on the locomotive's weight on the drivers, the scale being lower for a locomotive under 70 tons than for one above 70 tons. The steam engines which were replaced weighed 73 tons each.

"It is obvious, of course, that there is less wear and tear on the tracks and roadbed from lighter locomotives.

"As the fuel oil is automatically introduced to the engines, the duties of firemen have been largely removed. A fireman can now keep a constant watch for signals and for traffic on his side of the tracks, and materially assist the engineer in avoiding accidents and in speeding up switching operations."

All three of the new locomotives are on duty continuously during 6 days of the week. On Sundays, one suffices for the switching requirements, and the two others are given a routine inspection on that day. Every three months, each is given a thorough inspection. No overhauling has been found necessary as yet.

The locomotives in use were built jointly by the American Locomotive Company, the General Electric Company, and the Ingersoll-Rand Company.

Economy of Gas-Electric Car Operation by M. & O.

An evidence of the economy of operation of gas-electric motor cars is found in a recent compilation of data covering the 12 months of service from August 1, 1926, to August 1, 1927, by the Mobile and Ohio Railroad. This road operates two gas-electric cars a distance of 251 miles per day. Each car hauls a 35-ton trailer and has a gross train weight of 83 tons.

A total of 179,716 train miles was covered, using 86,339 gallons of gasoline, or 2.12 train miles per gallon. A total of 212 gallons of oil was used, averaging 70.31 train miles per gallon of oil. The total operating cost per train mile was 35.07 cents. The detailed data is as follows:

	Cents
Repairs—labor and material	2.16
Fuel—gasoline	6.17
Lubricants	0.67
Engine house expense—inspection	1.27
Other supplies and expense	1.25
Wages—train and engine crews	15.22
Sub-total	26.97
Substitute train service	2.71
Interest and dep.	5.39
Cents per train mile, total	35.07
Total motor car miles	169,174
Total steam train miles	10,543
Total train miles	179,716
Gasoline—gallons	86,339
Cost—gasoline per gal.	11.01
Train miles per gal. gasoline	2.12
Car miles per gal.	4.24
Oil—gallons	212
Cost—oil per gal.	46.32
Train miles per gal., oil	70.31

SUMMARY

Total schedule mileage	179,716
Total motor car mileage	169,174
Total steam train mileage	8,032
Total steam train mileage due to heavy traffic	6,024
Total steam train mileage due to motor cars out for repairs	2,510
(Equivalent to 10 days' operation in 12 months)	
Percentage of mileage covered	98.7

Freight Car Delays at Terminals

B. T. W.. Demarest General Superintendent Motive Power, Western Region, Pennsylvania Railroad

At the annual convention of the International Railway General Foremen's Association which was held in Chicago, September 6th to 9th inclusive, Mr. T. W. Demarest general superintendent of motive power of the Western region of the Pennsylvania Railroad deliverd a highly interesting address dealing with terminal delays to freight cars in which he discussed the many ways in which the mechanical department could aid in avoiding such delays. The abstract of Mr. Demarest's address follows:

With a net increase of only 56,419 cars, the railroads handled the largest volume of traffic in their history without any car shortage, there being in fact a large surplus of equipment, amounting on the average to 205,054 cars; that this accomplishment, insofar as car equipment is concerned, was brought about by: The retirement of inefficient equipment.

The statement shows further, that the average carrying capacity per car had been increased 2.28 tons per car, and that the miles per car per day had been increased from 25.1 in 1920 to 30.4 per car per day in 1926; these figures include all cars, that is, those awaiting repairs, surplus cars and cars in the hands of the shippers for loading and unloading.

The Car Service Division having the above facts before it, reported to the Directors of the American Railway Association, at their meeting last May, that in its opinion the business of the country for some time to come, could be handled with 100,000 less box and open type cars, provided in part that there be a continuation of the present plan of maintaining equipment in the best possible condition, and that there be a further increase of one mile per day in average car mileage per day. It is the mechanical department's relation to these two items that I propose to discuss.

The measure of the operating efficiency of any road, dependent of course, on the average length of haul, is car miles per car day, and just as a lack of track facilities for main line or yard service interfere with its free movement, so does the physical condition of the car interfere.

It is axiomatic, we believe, that the better general condition the equipment is kept in, the lower the average cost of keeping it in good condition and the shorter the time it must be held out of service for such maintenance. It is equally true, the better its general condition the more promptly it will pass through any terminal, no matter whether it is the question of interchanging it, loading it, or handling it through transportation yards or repair tracks.

The first essential then, in avoiding not only terminal delays but also road delays, is car equipment in good condition. You may not have a direct responsibility in the general maintenance condition, but at least you can keep the higher officers, who are responsible, in touch with the situation. There is no question, however, but that you do have a direct responsibility for detail conditions existing in cars that are (a) set for loading; (b) transportation yard inspection and road work; (c) repair track work and indirectly for defects brought about by rough handling in yards and on the road.

In discussing these matters with you, heavy repair cars will be given no consideration as, in our opinion, heavy repair cars should be taken care of at a process shop and not be handled as in ordinary repair track operation. It must be emphasized here, and throughout this entire discussion, that terminal delays to cars, and not only terminal delays but delays in road movement, are a joint responsibility of the transportation department and the mechanical department, and that no real progress can be made until those officers who have the authority, recognize this fact and set up all of the operations for the benefit of the railroad as a whole. Yardmasters are being pressed and criticized for their lack of prompt handling of cars through the yard, trainmasters for their failures to get trains over the road without delay, and the mechanical department for any slowing up in operation due to inspection or to repairs or delays to road movements brought about by equipment failures.

Past practice has limited the movement of the car, so far as reinspection and repair work is concerned, to division or crew changing terminals, which generally may be located an average of 100 miles apart. I am neglecting, of course, those interferences with longer movement brought about by classification practices and length of haul. This practice has interfered with the free movement of the car, taken additional time, reduced the car miles per day, and increased the inspection and maintenance expense. There is no reason why any of us should be content to perpetuate this condition.

Insofar as the locomotive is concerned, at one time its utilization was dependent on the same factors and its daily use restricted in the same way. There seems today no limit to the possible length of the locomotive run and the length of a locomotive trip has been increased from 100 miles to 500 and, in instances, to 700 miles. It has been accomplished by preparing the locomotive for the trip. Just so the utilization of the freight car may be increased, by properly preparing the car for its movement.

In your direct responsibilities there are two general situations. Ordinary transportation yard development consists of receiving, classification and departure tracks, although the two latter may be combined. Your responsibility begins before the cars reach the receiving yard—if off the road, not only the arrival time of the train should be known, but the track it will be yarded on and the makeup of the train as far as possible, i.e., whether it is slow or time freight, or a combination so that the inspectors may be properly located not only in reference to the arriving train, but also in reference to the work already in the yard.

Another primary essential is the education of the inspectors. Until the standard car is further developed, there will be different designs to accomplish the same purpose on different cars and the weak point of each design must be known so that an inspector may make his inspection thoroughly and in the minimum time.

A knowledge of those failures which are responsible for a majority of road detentions, and which should receive special attention before despatching the car, is also vital. The majority of road detentions today are brought about by hot journals and while some improvement may be noted generally, the number is so far beyond good practice that none of us have any reason to congratulate ourselves.

Next, and more serious, is the question of brake beams dropping down due to defective hangers, hanger pins and hanger pin brackets.

Next comes broken arch bars. The use of a mirror and a flashlight will detect any number of defective arch bars which escape the more casual inspection methods. Loose column bolts and box bolts are principally responsible for this condition. Worn holes in arch bars exert and influence. Frozen nuts on loose column or box bolts are too often neglected. Too many drawbars are pulled out. While this trouble may have its inception in rough handling in yards or on the road, the draft gear cannot be neglected. A knowledge of the vital points and how to look for them is most essential.

On arrival in the receiving yard, the train should be blue-flagged and thoroughly inspected. The character of the work done in this yard should be arranged so as to produce the minimum overhead delay to the car and the train. For instance, to use an extreme example, one would not try to change a pair of wheels in this yard, replace a brake beam or undertake the renewal of journal bearings. A cripple track should be provided so that as the train is classified, work out of the ordinary may be shifted out. Repairs may then proceed promptly while the work of shifting the train is done. Except in extreme case, the car can then be made ready to go forward in the train without delaying the car of the classification of the train and without increasing the time in the departure yard. Where the classification and the departure yards are combined, delayed movement is bound to occur as the repair men can do no work during the operation of classification, and if the tracks are short and cars have to be doubled over to obtain a road train further delays ensue. Packing and oiling can be probably best be done in the departure yard, which should be piped so that the air can be tested and repairs made to the brakes prior to setting out the road engine. Cars sent to repair track should only be those which cannot be handled economically or expeditiously on the cripple track. This is to avoid extra shifting and extra delay to the car. Cars sent to the repair track should be thoroughly and properly conditioned. As you complete a thorough inspection and repairs in your transportation yards, you will be interested to note that cars are returned from the repair tracks with detail defects not tolerated in your transportation yard operations. This should be corrected.

It seems needless to discuss ideal repair track layouts, the necessity for proper material supplies and tools. The correction of some of these items may require capital expenditures and others may be out of your direct control; but at least you can keep your superior officer in touch so that when the opportunity presents itself for improvement, he will know what to ask for and why.

You, however, may be able to increase your repair track output and decrease car delays by closer supervision over the cars as set on your repair tracks—not classification by destination, but classification by the amount of work to be done on the car. It is not unusual to see loads, two-day cars and one-day cars indiscriminately mixed on the same repair track, or if there is a separate track for the loads, cars on the same repair track with work on some which will prevent the release of the short time cars until the longer time cars are completed. Loads, long time cars, and short time cars should be spotted on different tracks. This promises advance knowledge of the condition of the cars before they are set and has generally received very little attention. If carried out, shifting will be reduced, cars will be released more quickly and the output of the track will be increased.

In any terminal the inbound business is generally distributed to connections, freight houses, team tracks or industries.

This is particularly true of points like Chicago, Cincinnati, St. Louis, etc., there being no beyond business on the same line. It is the practice on such a distribution, except bad order loads, to give the cars a running inspection only, with a safety appliance inspection on cars for interchange movement. If group prior classification has not been effected, the work of the inspectors and repairmen consumes more time than should be required.

As the cars to freight houses, team tracks and industries should, when unloaded, make outbound loads from the unloading location, while it may sound revolutionary, I am convinced that such cars should be conditioned before setting for unloading, and where this cannot be done, the car should be placed in the same category as a bad order load and shopped when empty. It is certain that if this practice is followed, time and shifting of the outbound load, will be saved. It is also certain that transfer cars would be pretty well eliminated. Our troubles today are largely due to the loading of improperly conditioned cars. The alternative would be to prepare the car at the point made empty. This in a terminal of any size is manifestly not practical.

While loads are usually received from connections to which cars are sent on order equivalent to the number of cars so sent, it is infrequent that the same empties furnished are returned as loads. The same is true of industries when served by more than one road, the shipper controlling the routing of the car. Consequently improvement in terminal delay, or any delay which will interfere with the free movement of the car, cannot be controlled locally, but can only be obtained by a united common movement by all roads. Cars are common property today, and as they follow the business are in fact operated in a general pool. This condition must be recognized in proper care of the car by the owner and proper care of the foreign car.

I desire to emphasize again the benefit to be derived from the development and adoption of standard cars. Not only will such cars be of generally better construction, but repairs while on foreign roads will be facilitated, material stocks will be reduced, and the inspection and inspection repair work will be speeded up. In effect the car will move more freely and with less delays, material will be common and delay on repairs due to the necessity of ordering special material or material from the owner, will be eliminated. The reason for the delay in the development and the adoption of standard cars is not far to seek, and can be overcome by action on the part of the American Railway Association.

Too many delays occur in the handling of repair track cars, from the time they are shopped out in the transportation yard until they reach the repair track, and also to some extent on their return movement. A detailed daily record of some movements will very quickly develop the slow point, and a potent cause for car delay can be eliminated. The general foreman and the yardmaster must work together to accomplish this, and again, the result can only be obtained by all departments recognizing what is best for the railroad and not what might be most convenient for one department. This applies not only to the loads, but to the empties as well.

Aside from some weak car constructions and an insufficiently high standard of general maintenance, depreciation of the equipment, bad order and shifted loads which cause transfer and the inspection and inspection repair work are very seriously affected by the character of the handling in transportation yards and on the road. There is no doubt but that changed transportation yard methods, the effort to speed up the yard handling of cars, the increased number of cars in road trains, and the increased speed and weight of such trains exercise a serious effect on car conditions and make bad order and weak cars. The general foreman must keep in touch with bad order cars developing from insufficient care in handling, and in conjunction with the yardmaster and, if necessary, his own superior officer, bring the facts before those who can correct the situation if it cannot be corrected locally.

In reviewing the entire question, I cannot see any new principles involved. The causes for delays and their remedy are in full view. The limit in operating and maintenance costs has not been reached and we have not yet begun to utilize fully or to obtain paying service from our freight cars. Not only can the paying time of freight cars be increased, but by so doing the capital invested in freight cars can be decreased. To obtain these results may mean change in policy and change in methods. It certainly requires common action, not only as between the departments on an individual road but also common action on the part of all roads. In the past we have been prone to say "We can't afford to do it." It seems to me we have reached the point where we must say "We can't afford not to do it."

Three Cylinder Locomotives

By Robert Hughes

The piston locomotive of today has gone through three stages of development in order to gain steam economy. First the use of compounds was resorted to, then the application of superheated steam was made, and finally, the use of feedwater heating entered locomotive practice.

We are now facing the problem of further increasing the power and capacity of the locomotive power plant and among recent developments is the use of three-cylinder locomotives either simple or compound.

The subject of three-cylinder locomotives suggests that a review of the development as to cylinder arrangements with a view to increasing effective utilization of steam may be of interest.

Locomotives Classed as to Cylinder Arrangement

Simple: 2-cylinder, 3-cylinder, 4-cylinder.
Two-Cylinder Compound:
1 High-Pressure Right.
1 Low-Pressure Left.

Three-Cylinder Compound:
1 High-Pressure Middle.
2 Low-Pressure Outer.
or
2 High-Pressure Outer (Webb).
1 Low-Pressure Inner.

Four-Cylinder Compounds:
2 High-Pressure outer 2 Low-Pressure inner, in different planes and different axles (de Glehnn and Cole).
2 High-Pressure inner 2 Low-Pressure outer or reverse.
All axles in same plane (Borris, Vauclain).
2 on each side, Tandem High-Pressure and Low-Pressure cylinders as in Hungary and the United States.
2 on each side, High-Pressure and Low-Pressure one above the other with same cross head (Vauclain).
2 High-Pressure one side and 2 Low-Pressure on the other side.
Separate drives 2 High-Pressure on solid frame and 2 Low-Pressure on flexible base (Mallett, Rimrott).

It is of interest to note that up to 1908, after the introduction of Webb three-cylinder compound in 1885 on English railways, but one continental railway continued the use of three-cylinder locomotives, namely the Jura Simplon Railroad Co. It is also of interest to note that even back in the early history of the steam engine that apparently successful use was made of a three-cylinder construction by Robert Stephenson & Co., according to the *New Castle Chronicle* of May 7, 1847, from which we quote the following record:

"A special train of five carriages was taken from London to Birmingham, 112 miles, yesterday (Wednesday) morning in 2 hours and 30 minutes. The actual time of travel did not exceed 2 hours, being an average speed of 56 miles per hour, the train being stopped four times on journey to allow other trains to clear the line besides stopping to Wolverton to change trains. The engine which started from London, No. 157, is one of Mr. Stephenson's ordinary patent engines (i.e.) (rear drive long boiler locomotive), and the latter part of journey of 21 miles, was performed in 21 minutes.

"The maximum speed was 75 miles per hour. The engine from Wolverton to Birmingham was also a patent engine of Mr. Stephenson's having 3 cylinders, and it performed the first part of journey of 41 miles, until it was stopped and held by another train, in 42 minutes. Maximum speed on this portion of the journey was 64 miles per hour. We understand that Lord George Bentnick and several gentlemen going to Chester races were in the train. A side wind was blowing throughout the journey. Mr. McConnell (Locomotive Superintendent of London and North-Western Railway Company) and Mr. Winters (the superintendent of Mr. Stephenson's patent engines) were on the engines and described the motion at highest velocity to be perfectly steady. The three-cylinder locomotive that hauled the train (patented by Stephenson and Howe under date of 1846, Patent No. 11086), from Wolverton to Birmingham was fitted with two small outside cylinders, one large cylinder in center line of engine having a capacity equal to that of two outside cylinders. The three cylinders had a total capacity equal to that of two cylinder engines of the type then in vogue. The cranks of the two outside cylinders were placed on the same dead center on either side, both cranks being up or down simultaneously. The object of this arrangement was elimination of rocking effort produced in two-cylinder engines by the upward thrust of connecting rods on slide bars acting alternately in opposite directions. Incidentally, there resulted from the new arrangement an elimination of swaying motion due to the action of outside reciprocating masses in two-cylinder engines having cranks at right angles."

The foregoing excerpt shows that the three-cylinder locomotive is hardly a new idea and that eighty years ago, the pioneer locomotive builders worked it out, at least successfully.

The use of three-cylinder locomotives are being widely made and in this connection one may refresh his knowledge as to Bulletin No. 2003, American Locomotive Company and paper by R. Eksergian of the Baldwin Locomotive Works presented to the Oregon Section of the A.S.M.E. in May, 1926, or the bulletins of the Lima Locomotive Works, in order to show how some of the progressive engineers have thought on 3-cylinder locomotives.

In 1914, J. B. Ennis, Vice-President of the American Locomotive Co., said that little consideration had been given to the advantages of the three-cylinder arrangement, and few locomotives of that type were in successful operation. He also said: "As compared with the four-cylinder engine, either simple or compound, the three-cylinder offers first the possibility of increased power. With one cylinder located between frames, ample room is provided for a properly designed crank axle and main rod which cannot be arranged in the four-cylinder type beyond a certain limit. As compared with the two-cylinder engine, the advantages are, briefly; a more even turning moment, an ideal counter balancing condition and opportunity to furnish maximum power with minimum destruction effort on rail. The power obtained from a two-cylinder engine with 27 in. diameter and a maximum piston thrust of 117,000 lbs., can be obtained in a three-cylinder engine with cylinders 22 in. in diameter and a maximum thrust of 78,000 lbs. This decrease of 33 per cent in thrust, means a corresponding reduction in individual weights of all of the machinery, particularly the reciprocating parts. The three-cylinder engine however, offers advantages possessed by no other arrangement, and it would seem that, for high speed passenger service at least, this type is well worth considering for the future."

The three-cylinder compound is advocated to allow of a reduced cylinder diameter and piston thrust, and a more uniform turning moment.

There is no doubt but that the steam locomotive by use of 350 pounds boiler pressure and three cylinders can gain at least 15 per cent greater hauling capacity and 15 per cent greater economical operation than a two-cylinder engine.

Guaranty Settlements Nearly Completed

As of September 30 the Interstate Commerce Commission had settled all but 13 of the remaining claims of carriers for the guaranty under Section 209 of the Transportation Act for the six-month period following the termination of Federal control in 1920.

There were 667 carriers that accepted the guaranty and their claims amounted to $656,863,422. The cases of 134 were dismissed and 520 have now been settled.

The certificates issued by the Commission for the cases settled amounted to $526,887,109, including advance and partial payments, and $3,005,510 has been certified as advance and partial payments for the cases not settled, making the total certifications $529,892,619.

The balance payable on the unsettled cases is estimated at approximately $830,000. In its 1921 annual report the Commission estimated the amount necessary to make good the guaranty at $536,000,000 and in later reports has adhered to that figure.

Convention of Traveling Engineers' Association

Reports on More and Better Utilization of Locomotives and the Use of Boiler Pressures of More Than 200 Pounds

Continuing the report of the annual convention of the Traveling Engineers' Association as published in the previous issue, abstracts from the other reports to the association follow:

Previous to recent years when the greater utilization of power began to be appreciated to a broader extent than in the past, locomotives were confined to districts usually limited by schedule provisions governing the engineman. It was a universal practice to terminate the runs of the engine crews and locomotives at the same point, and as a consequence the expensive machines were idle or non-productive approximately two-thirds of the time. In the last five years, however, the possibilities of continuing the locomotives in service beyond the formerly established limits, running the same locomotive over several enginemen's divisions has come to a greater realization, and yet it is safe to say that the development of long locomotive runs is still in its infancy.

It is an established fact that a small number of units making a large daily mileage, can be maintained at a lower cost than a large number of units making comparatively low mileage. It is, of course, true that a locomotive making 400 miles a day will require a little more attention at the end of its run than a locomotive making only half that mileage, and it is also true that the shopping periods will come due at shorter intervals, but these factors are not objectionable. It is recognized that fewer locomotives in service result in less capital invested to move a given business, and in addition, such fixed items as engine handling, fire cleaning, wiping, testing, inspection, etc., have to be done to fewer locomotives and thus the general locomotive cost is considerably reduced. Another factor, and a very important one, is the fuel saving possible, because the fewer locomotives in service the smaller will be the stand-by losses.

Another important factor is the reduction in the amount of boiler and firebox repairs brought about by extended runs due to eliminating the amount of cooling down of boilers and firing up at intermediate terminals.

When extended locomotives runs were first inaugurated, the tendency was to discourage the attempt, picturing an increased ratio of engine failures, etc., but instead, the experience has been that because of the longer runs, more careful terminal attention is necessary, and as a consequence the service has not suffered, but has materially improved.

The utilization of locomotives is a matter of sufficient importance that the American Railway Association has appointed a joint committee consisting of three operating heads and three mechanical heads to make a study of the operations and methods followed by different railroads in utilizing their power. This committee, through the American Railway Association, has issued statistics as to locomotive performance for Class I railroads.

These show considerable variation in miles per active locomotive per day for the different railroads. However, there has been a considerable improvement in average miles per active locomotives by Class I roads, as is shown by the following tabulation for the years mentioned:

	Freight	Passenger
1923	81.6	142.6
1924	79.1	143.0
1925	82.3	147.7
1926	85.0	151.9

Many railroads are making from 11,000 to 12,000 miles per month per active passenger locomotive, and from 5,000 to 6,000 miles per month per active freight locomotive by operating extended locomotive runs and giving careful attention to reducing the non-productive time to a minimum. In securing this mileage per active locomotive, the 24 hours of the day is divided into approximately 12 hours productive and 12 hours non-productive time. Further sub-division of non-productive time is divided into approximately 8 hours for mechanical attention and 4 hours for transportation delay, awaiting trains.

With ideal facilities for maintaining and turning power, it is a simple matter to speculate on what may be done in the way of turning power to secure a greater utilization, but the question of importance is how close may the maximum utilization be approached with the facilities now at hand. The character of business, type, and size of power, terminal facilities, location of terminals, schedule of trains, quality of boiler feed water, quality of fuel, and profile of road are important factors which vary on different divisions and on different railroads, and have a bearing on the utilization that may be secured. These conditions make it necessary that all railroads analyze their own operation and conditions to satisfy themselves that they are getting the greatest possible utilization of their locomotives.

It is important that terminals be provided with adequate machinery facilities to perform the character of work to be handled. Roundhouses should be of sufficient capacity and properly equipped with the necessary drop pits, wash out plants, blower systems, heat and light, adequate fuel, sand and cinder handling facilities, etc.

In order to secure more and better utilization of locomotives, it is necessary that the time undergoing heavy running and classified repairs be reduced to a minimum. Considerable improvement along this line may be made by arranging shop forces and repair forces so that the work will be carried on continuously throughout the 24 hours, instead of working on the locomotive only 8 hours per day.

In order to intelligently supervise the utilization of power the local and division supervisors should have information showing the average miles per active locomotive per day, in freight, passenger and switch service, as well as information showing the distribution of non-productive time from the time locomotives arrive at the terminal with train until again leaving the terminal. It is important that the daily average miles per active locomotive be condensed into a weekly report, and if the mileage shown is lower than the expected mileage for a division, the matter should be investigated to see if there are too many locomotives in service. Such a condition will also be reflected by the reports on non-productive time, which will show either excessive time undergoing repairs, or awaiting trains after repairs are complete.

A frequent exchange of information as to power that will be ready and trains to be run is important, and close co-operation between the roundhouse foreman and transportation department representatives is necessary to efficiently maintain power with the minimum of delay. Greater utilization of locomotives can be secured if roundhouse foremen know certain locomotives in their terminals will not be used for 12 or 15 hours. This amount of time will enable them to make repairs during the layover, which otherwise would require holding the locomotives out of service on the next trip.

On many railroads it is necessary to wash boilers after each trip, or in some cases each round trip. The time required to wash boilers is usually the governing factor in time, required to turn locomotives, which makes it important that this time be reduced to a minimum. Roads that have good water conditions, which result in less frequent boiler washings, may be expected to maintain a greater utilization of locomotives than roads operating in bad water territories. The type and size of power has an important bearing on the time required for mechanical attention. Large freight and passenger power on heavy grades with a high mileage per dispatchment will require more man hour's work to make locomotives ready for service than lighter power on short runs.

Many railroads have adopted the policy of making thorough inspection and repairs to locomotives at the time of monthly inspection, resulting in placing locomotives in condition to run to the next monthly inspection period, with a minimum terminal delay for repairs. This enables quick turning of locomotives between monthly inspection periods, and has resulted in improved conditions of locomotives during this term of service, which increases the amount of productive time during the month.

Each locomotive in the assignment on extended runs should have a specific terminal where this locomotive is to be maintained, and the foreman in charge of this terminal should be responsible for its condition. The delay at intermediate terminals and at turn around terminals should be reduced to the minimum and the locomotive held at the maintenance terminal sufficient time to perform the necessary work to place it in condition to make the round trip, with minimum attention. This program will permit the concentration of repair work at terminals where the most modern facilities are provided, and will affect economies in cost of locomotive repairs, handling, and fuel consumption.

The standard of locomotive maintenance on extended runs necessarily must be higher than on short runs, and this standard of maintenance to a large extent governs the length of runs. A number of railroads have made experimental locomotive runs in excess of 1,000 miles, after placing the locomotive as near as possible in 100 per cent condition. This indicates that the locomotive is capable of running over several divisions if properly maintained. The trend of the future is that locomotives will run wherever the train goes rather than being confined to a particular territory, especially where the train consists and profile of the road will permit.

Any change in the established locomotive runs must be properly supervised to insure successful operation. The enginemen should be educated and instructed in the handling necessary on the extended locomotive runs, because if this work is not properly supervised, the probability is that the establishing of long runs will not effect the economies desired and failure is almost certain.

The extension of locomotive runs has shown the need for greater lubricator capacities for valve and cylinder lubrication, as well as large capacity grease cups for crank pin lubrication. Improvements in design have been made which tend to reduce the need for repairs, as well as the time necessary to perform such work, such as floating rod bushings, solid front end main rod brasses, improved cylinder packing rings, floating hub liners, long piston rods, special materials for certain wearing parts, standard design of parts for interchange between classes of locomotives, increased capacity of locomotive tenders, large ash pans, etc.

On extended locomotive runs it is highly important that a uniform grade of fuel be furnished over the entire district rather than mixing various grades and qualities of fuel indiscriminately. Good results are being secured with a uniform quality of coal of a low grade where suitable grates, ash pan and draft appliances are provided.

The maximum daily locomotive mileage cannot be accomplished without the close co-operation between the mechanical and operating departments. It is essential in scheduling trains on the roads and arranging the various switch and transfer engine assignments in a terminal, that careful attention be given to the possibilities of utilizing the power to the greatest extent.

A more and better utilization of yard switch power is deserving of study to determine whether the greatest amount of service is being secured from the locomotives assigned. There are yards on many railroads where switch locomotives assigned average 16 hours service out of each 24 hours, and as far as is practical, switch locomotives should be worked in the yards continuously during the tour of duty of two or three switch engine crews.

In order to effect the greatest economy from the operation of locomotives, it is necessary that locomotives handle the maximum tonnage consistent with speed. There is considerable variation in the gross ton miles per freight train hour, some of which is possibly due to heavy grade conditions and character of business handled. Many roads are showing improved locomotive performance as reflected by the substantial increases from year to year in the gross ton miles handled per train hour.

The delay to trains en route over a division must be given careful thought to avoid every unnecessary stop. As far as possible trains should be run at the time of day when the least interference will be encountered. The leaving time of trains at terminals should be anticipated and the locomotives ordered and furnished promptly at the designated time. It is important that locomotives move from the engine house to the train yard, and from the train yard to the engine house with the minimum delay to locomotives, as well as the minimum delay to yard operation.

The roadway facilities have an important bearing on the number of hours required to move trains from the initial to final terminals. Among the most important of these are the location of fuel and water stations, efficient blocking of trains, proper length of sidings, double track, facing point cross overs, adequate signaling, lap sidings, remote control switches, etc. With the establishing of extended locomotive runs, it is desirable to have fuel, water and sand facilities on the main line at intermediate terminals when such facilities will avoid having to take locomotives to the roundhouse for this attention. Provisions should be made to allow these facilities at intermediate terminals to serve the terminal as well as the main line.

Any program which is worked out to increase the utilization of locomotives must give the greatest number of hours of productive service or mileage per month with the minimum terminal time undergoing repairs and delay awaiting trains. The hours of service or mileage of locomotives must be made to produce the maximum of useful work in order to secure the greatest return from the investment. A study of the operating conditions of each railroad may facilitate the movement of a considerably increased business without additional expenditure for locomotives or facilities.

The committee that presented the foregoing report consisted of J. W. Nicholson, chairman, C. J. Barnett, J. E. Bjorkholm, Robert Collett, J. J. McNeil and Frederick C. Wendt.

Boiler Pressures Higher Than 200 Lb.

During the last few years, opinion has been gradually crystallizing in favor of higher boiler pressures for steam locomotives. From present activities, we appear to be entering an era of thermo-dynamic improvement, similar to that brought about by the introduction of superheating, some 20 or 25 years ago, and as the latter had its greatest impetus from German engineers, so, at the present movement, it appears that the Germans are just now taking the lead in the development of ultra locomotive boiler pressures, closely followed by the Swiss.

The outsanding advantage of high pressure, namely, extra available heat energy from a given fuel, will continue to invite the activities of engineers working on different lines of thought, which will advance development toward the ultimate boal of what we consider today an ultra-pressure. These are greater difficulties to overcome in the development of high steam pressures than in the development of high steam temperatures by superheating. On the other hand, the incentive for economy today is much greater than 25 years ago.

While no serious attempts have been made in this country to use ultra-high pressures, there are a large number of locomotives running with the lower range of high pressures. There are somewhat over 1,000 American locomotives using 250 lb. pressure, and others being constructed. As a whole, there are no distinctive departures from convention in the design of these locomotives, excepting that they are as a rule arranged for limited cut-off—usually 50 or 60 per cent maximum.

There are also a number of locomotives operating on one road in which a boiler pressure of 265 lb. is used. These are equipped with McClelland water-tube firebox boilers, but in other respects of conventional design.

The use of pressures above 265 lb. is apparently confined to the following examples: the Delaware & Hudson "Horatio Allen," using 350 lb. boiler pressure; the "John B. Jervis," of the D. & H., which will use 400 lb. boiler pressure, and the Baldwin Locomotive Works No. 60,000 which uses 350 lb. steam pressure. Data from the Altoona test plant is now published and shows this locomotive as having produced greater fuel economy than any other locomotive tested in this plant, and service tests on several prominent roads appear to sustain these figures.

As a result of the use of higher pressures, limited cut-off and compounding, locomotives of the types mentioned show favorable reduction in steam consumption; in most instances an increase in tractive effort.

Several other roads are at present favorably considering new locomotive design including steam pressures from 400 to 500 lb.

European Developments

European experiments and developments in high-pressure locomotives embrace a variety of ideas, some of which are a distinct departure from present accepted practices. Particularly are European engineers and railway men interested in pressures in excess of those under present consideration in America.

Several high pressure locomotives have been constructed and are under test on European railways. Some of these have interesting possibilities. As no detailed information is available on most of this experimental equipment, the descriptions contained herewith are necessarily brief.

The "Schmidt-Henschel two-pressure" locomotive is an unusual unit which was constructed at the Henschel-Sohn works at Cassel, Germany. It is now undergoing test operation on the German State Railways.

Three pressures are produced in the boiler, although but two, the 850 lb. and the 200 lb., are working pressures. The 850 lb. pressure is superheated to above 716 deg. F. and worked expansively in center high-pressure cylinders. It is exhaused at about 200 lb. pressure, mixed and reheated with fresh superheated steam from the low pressure part of the boiler and then expanded in the two low-pressure outside cylinders. The low-pressure steam is highly superheated so that the resultant temperature, after mixing with the steam which has been cooled by cylinder expansion, is at a temperature of about 660 deg. F., as it goes to the low-pressure cylinders. The final exhaust is through the stack in the usual manner. A feedwater heater and sediment separating arrangement is provided for the low-pressure boiler, and feedwater for the high working pressure drum is pumped from the low-pressure boiler.

Some of the advantages expected of this design are as follows:

1—Freedom from scale in the firebox portion of the boiler, because of the use of distilled water; the absence of fire contact surfaces and the use of clean water in the drum portion; and the lower pressure and sediment separation arrangement in the low-pressure part of the boiler.

2—Freedom from cylinder condensation because of the reheating effect of the highly superheated low-pressure steam upon the expanded steam with which it is mixed as it passes to the low-pressure cylinders.

3—Relatively high overall economy as a result of the inherent economy of the high-pressure steam, reheating and compounding, and the efficient heat flow from flame and hot gases to the water.

This locomotive was converted from an ordinary three-cylinder locomotive developing originally 1,800 hp. In its present high-pressure form the output is 2,000 hp. No operating data indicating the efficiency obtained is as yet available, but your committee is in correspondence with Henschel & Sohn, also the German State Railways, to develop this data. We have learned in a general way that the results of preliminary tests are very encouraging.

Buchli locomotive—Another development worthy of attention in a high-pressure locomotive designed by Dr. Buchli and built by the Swiss Locomotive Works, Winterthur, Switzerland. The boiler is a water-tube type development, 800 lb. direct pressure and is equipped with feedwater heater, superheater and air preheater.

The engine is very unusual, being a small high speed three-cylinder, horizontal, uniflow type with poppet admission valves—the cylinders are only 10 in. diameter. All parts are enclosed and run in oil, including filter, force-feed and oil cooler. It is geared to the drive wheels with two to one ratio gears and, being a complete unit, can be removed as such from the locomotive. The exhaust pipes or passages from each of the three cylinders terminate in a "Y" formation so that each exhaust impulse will produce an ejector effect on the two other cylinders and thus reduce the effective back pressure.

Some advantages Dr. Buchli is striving for, and from indications of tests may attain, are:

1—High overall efficiency.

2—Low first cost, and reduction of wear and cost of servicing through use of small light weight reciprocating parts.

3—Ability to operate at a high cut-off point. It will start loads of 27 per cent, shows good indicator cards at from 9 to 12 per cent, and operates easily at 5 per cent cutoff.

4—Elimination of dynamic augment as counterbalancing of revolving parts only required.

5—Low adhesion factor because of the twelve impulses per revolution of drive wheels.

In preliminary tests this locomotive is reputed as showing a net efficiency of 11 per cent and a smooth performance mechanically. The Buchli design as a whole represents a marked departure from conventional design, both as to boiler and machinery, and illustrates the boldness of European locomotive designers.

Maffei turbine locomotive—Still another development of a different character is the Maffei turbine locomotive built by J. A. Maffei of Munich, Germany, for the German State Railways. This locomotive develops 2,500 hp. and was designed to haul heavy express trains at an average speed of 62 m.p.h. The design is particularly adapted for high speed.

The turbine is mounted at the front and is geared to a jack-shaft from which the final drive to three pairs of drivers is by side rods. The exhaust steam is condensed in two surface type condensers mounted, one on each side of boiler, below running boards, the water for the condensers being air cooled in the water cooler portion of the tender. A turbine-driven fan creates the necessary draft for ejection of waste furnace gases. Mechanical draft becomes a simpler problem when handling the waste gases only. Other auxiliaries are likewise turbine driven. Of particular interest is the use of 324 lb. pressure in the boiler of ordinary stayed sheet firebox type.

This locomotive is a highly advanced example of engineering skill and may indicate one of the several means toward attaining high economies with steam locomotives. Advantages anticipated from the design are:

1—High overall economy as a result of high steam pressure, turbine drive and condensing. The builders expect an efficiency at the turbine jackshaft of 15.6 per cent at a speed of 43.5 m.p.h.

2—Lighter total weight per horsepower, these particular locomotives being 18,000 lb. lighter than corresponding lower pressure reciprocating types of equal output.

3—Elimination of dynamic augment as the counterbalancing of the side rods only is required.

4—Low adhesive factor as a result of the uniform torque.

5—Freedom from scale formation because of the condensing.

6—Quietness of operation.

Ljungstrom turbine locomotive—Another locomotive using pressures higher than ordinary in a boiler of conventional type is the Ljungstrom turbo-locomotive. This is a Swedish design, the first being constructed in Sweden for the railways of that country, and later, one in England for use in that country. The steam is produced at a pressure of 285 lb. in a boiler of conventional construction, mounted upon a framing and wheels forming the "boiler vehicle" or forward part of the locomotive, but contributing none to the adhesive weight. The turbine, which is of 2,000 hp. capacity, is mounted upon the tender or rear portion of the locomotive and geared to the wheels thereof. The advantages and disadvantages of this type of locomotive correspond practically to those mentioned in the description of the Maffei turbine locomotive, the variation in design being in the details rather than in general principles.

Comparative performance tests were made with turbo and reciprocating types of locomotives, figures given being pounds of coal per 1,000 ton miles.

Turbo locomotive—highest, 4.5 lb; lowest, 39.1 lb.

Reciprocating locomotive—highest, 130 lb.; lowest, 82.9 lb.

Comparing the average turbo performance with the lowest for the reciprocating type shows a saving in coal consumption of 49 per cent. The comparison would be a less favorable one if made with some of the latest examples of American locomotives.

Other forms of turbo-locomotives, such as the Krupp and Zoelly designs, which are to be adapted to the use of high pressures, are under development and test.

Krupp turbine locomotive—The locomotive as now being constructed is to have a maximum output of 2,500 hp. and use a pressure of 854 lb. The boiler is constructed similar to the Thorncroft-Schultz marine boiler, that is, with top and bottom drums connected with water tubes. Construction of this locomotive will not be completed until tests of the present Krupp low pressure turbo-locomotives are completed.

In consideration of turbine locomotives which seem particularly well adapted to the use of high steam pressures, some factors must be considered which counteract to an extent the advantages derived therefrom. They at present seem to be adapted principally to high speed passenger service, are relatively complex in design and construction, and the first cost is much greater than conventional design. In Germany this increase in cost has been found to be about 80 per cent, although development may reduce that figure somewhat. If the economies expected are realized, the first cost may become of secondary importance.

Loeffler locomotive—Two locomotives of the piston type are being built by the Berlin Machine Builders to the designs of Prof. Loeffler. These locomotives are reported by Dr. Wagner of the German State Railways to have characteristics about as follows: 2,500 hp.; boiler pressure, 1,422 lb. The boiler consists of a high-pressure drum containing water and a tube type superheater.

Saturated steam is pumped from the drum through the superheater coils, 25 per cent of the steam going to the engine cylinders and the balance returning to the boiler drum, where it is injected into the water. Here it gives up its residual heat to the water, generating saturated steam which continues on through the cycle. The steam used in the cylinders after performing its work is condensed and the water returned to the boiler. Hot combustion gases come in contact only with coils or boiler tubes containing steam. A fuel economy of 45 per cent is anticipated, compared with usual conventional design.

In addition to the examples cited, other high pressure experimental locomotives are under construction, but concerning which little information is at present available.

Present and Future Locomotive Developments

There are greater difficulties to be encountered in the construction of high-pressure water-tube boilers and their associated working apparatus in the case of locomotive than in stationary plants, particularly in the matter of space limitation, yet undoubtedly some of the knowledge gained in the high pressure stationary experimentation can be made use of in connection with locomotive work.

In connection with design and construction of locomotives using high-pressure steam—there are two major problems which must be given due consideration and study. They are: First, the means of producing the high-pressure steam, viz.; the boiler and its various associated appurtenances; and second, the apparatus for working or using the steam, whether piston type engine or turbine, and its various associated or connected parts. It is necessary that we feel our way, try various ideas and select those that survive through their natural fitness.

There is one requirement which must not be overlooked—that of reliability. The ability to move the traffic over the road at all times and under all conditions, good or adverse.

The fire-tube boiler now in general use is reliable, compact, low in first cost, has great evaporative capacity in relation to space occupied, and in addition it has the advantage of great energy storage capacity which is of value on account of the sudden fluctuation of demand upon the motive unit.

It is, however, limited somewhat by reason of the excessive thickness and weight of sheets required for high pressure, this being the reason for adoption of water-tube principle in most of the recent experimental units. The general use of higher boiler pressures which seems inevitable spells the doom of the boiler with staybolted surfaces; and, with our staybolt troubles, we should not be sorry to see it pass. The Brotan, McClellan, Muhlfeld, and other boilers are indicative of the trend toward the water-tube. These boilers operate under pressures of 250 to 400 lb. Higher pressures than these will compel a still further application of the water-tube boiler principles to the extent of displacing the shell and fire tubes.

The use of alloy steels will assist in the reduction of this limitation as is apparent by the use of nickel steel on some Canadian Pacific locomotives whereby it was possible to increase the steam pressure from 200 to 250 lb. with no increase in the thickness of the boiler shell, firebox sheets and diameter of stays.

Controversial ideas have been expressed as to the maximum pressure practical to use in the ordinary stayed type of firebox, these centering largely on a pressure of 250 lb. as a limit. Upsetting somewhat this arbitrary limit, it is noted that two European locomotives previously described are using pressures of 285 lb. and 324 lb., in boilers of ordinary construction. These are the Ljungstrom and Maffei turbo-locomotives. These are, of course, smaller than prevailing American equipment, and the pressures indicated are lower than those now contemplated by many designers.

In connection with the construction of water-tube boilers for locomotives, some difficulties may be encountered in keeping tube connections tight, and it is more difficult to construct a rigid unit such as is required in locomotive work, than is the case with conventional type of boiler. Some loss in heat storage capacity will result from the reduced volume of water under pressure, but this may be compensated for to an extent by more flexible steaming capacity.

One difficulty which may present serious aspects in connection with the high-pressure boiler lies in the very general use of untreated water. With the high temperature used this may be serious and washing and cleaning may become burdensome. Boilers so designed as to obtain a rapid circulation will avoid much of this difficulty. The use of condensing as on turbo-locomotives would, if practical to apply to our large units, practically solve this difficulty. Experience with the Brotan, McClellan and Muhlfeld water-tube firebox indicates that scale formation, cleaning and inspection, does not present the difficulties that were expected and it is possible that with reasonably good water, difficulties along this line will be minimized.

Many conceivable arrangements may be suggested for the working or expansion cycle of a high-pressure locomotive. The use of high-pressure steam and multicylinder design tends to improve the construction through the use of smaller parts and the greater possibilities for work production of high pressure steam. The multicylinder construction reduces the necessary adhesion weight on account of more uniform torque action, this approaching to a certain extent that quality which is quite characteristic of the turbine.

Turbine locomotives have some interesting possibilities, although those built so far in Europe do not exceed 2,500 hp., being of smaller capacity than would be required for general service in America. The designing of a condenser for turbine locomotives of 4,000 or 5,000 hp. might present quite a problem.

Proper superheating will, of course, be important, but rather than add a high initial superheat, it seems preferable to use a moderate initial superheat, expand the steam in more than one stage, and reheat between stages. Losses from condensation would be reduced and the superheating between expansion stages would be effective because of the greater temperature difference at that time between the steam and the furnace gases.

Your committee does not feel that the present-day development of the higher pressures offers opportunity to suggest any recommendations, and desires this paper to be accepted as an outline report.

The report of the subcommittee on High Boiler Pressures is signed by A. H. Felters, (Chairman), W. I. Cantley, H. M. Warden and M. F. Fox.

New Safety Record in Train Accidents

A new record in safety was established by the railroads of this country in the first six months this year when only two passengers lost their lives in train accidents, according to reports just filed by the rail carriers with the Interstate Commerce Commission.

This was the smallest number of fatalities among passengers resulting from train accidents ever reported for the first six months in any recent year. In the first half of 1926, fatalities among passengers, as a result of accidents to trains, numbered 22, while there were 52 in 1925, 23 in 1924, and 8 in 1923.

Passengers injured in the first half of 1927 as a result of train accidents numbered 776 compared with 656 in the same period last year and 758 in 1925.

Decrease in Other Accidents

In other train accidents, 38 passengers lost their lives in the first half of 1927 compared with 41 in the same period last year. Of the 38, reports showed 19 were killed in getting on and off cars or locomotives, while eight were killed by being struck or run over not at public crossings.

This improvement in safety has been largely brought about by the intensive safety campaigns which the railroads have been conducting and also through the use of steel cars and other improvements in the mechanical facilities of the railroads.

Grade Crossing Accidents Decrease

A total of 1,062 persons lost their lives in grade crossing accidents in the first six months of 1927. This was a decrease of three compared with the corresponding period last year.

Persons injured in grade crossing accidents in the first half of 1927 numbered 2,901 compared with 3,110 in the same period one year ago or a reduction of 209.

Reports showed 2,561 grade crossing accidents occurring in the first six months this year compared with 2,644 in the same period in 1926 or a reduction of 83.

A widespread and intensive campaign to impress upon the public the necessity for greater care being exercised in passing over highway grade crossings is being conducted by the railroads of this country through the American Railway Association. In addition, rail carriers are endeavoring to provide the greatest possible safety at highway grade crossings.

Progress Is Being Made

A slight decrease in the number of accidents and fatalities at such crossings in the face of an increase of more than two million in the number of automobiles in use indicates that some progress is being made in this campaign, but only through the co-operation of the public and the railroads can a reduction in such accidents be realized, particuluarly in view of the fact that complete elimination of highway grade crossings is both physically and financially impossible.

Direct Service Between France and Egypt

Railway service between Calais, France, and Assuan, Egypt, will be inaugurated on November 1. Passengers on the Simplon Orient Express, one of the most famous European trains, upon their arrival at Constantinople will be ferried from Sirkedji, the railway terminus on the European side of the Bosphorus, to Haidar Pasha, on the Asiatic side, where they will again continue their rail travel through Asiatic Turkey. At Eski Chehr, the railway junction for Angora, the train will be divided into two sections, one part going to Angora while the other will continue to Aleppo and Tripoli. At Tripoli the passengers will be transferred to automobiles and conveyed to Haifa, Palestine, where they will resume their travel to Assuan. The service will be operated three times a week. The trip from Calais to Assuan will take 120 hours. International sleeping cars and diners will be a part of the equipment.

Motive Power in Excellent Condition

A new low record in the number of locomotives in need of repair was established on October 1 this year by the railroads of this country, according to the American Railway Association.

The total number of locomoitves in need of repair on that day, according to reports just filed by the carriers, was 8,345 or 13.6 per cent of the number on line. This was a decrease of 157 locomotives under the best previous record which was established on September 1 this year, at which time there were 8,502 or 13.9 per cent.

The number of locomotives in need of repair on October 1 was a decrease of 618 compared with the number of such locomotives on September 15, at which time there were 8,963 or 14.7 per cent.

Locomotives in need of classified repairs on October 1 amounted to 4,484, or 7.3 per cent, a decrease of 265 compared with Septembr 15, while 3,861 or 6.3 per cent were in need of running repairs, which was a decrease of 353 compared with the number in need of such repairs on September 15.

Class I railroads on October 1 had 5,720 serviceable locomotives in storage compared with 6,031 on September 15.

Notes on Domestic Railroads

Locomotives

The Detroit & Toledo Shore Line is inquiring for 4 Mikado type locomotives.

The Winston-Salem Southbound Railroad is inquiring for a locomotive tender.

The Missouri-Illinois Railway has ordered from the American Locomotive Company 2 consolidation type locomotives.

The Argentine State Railways are expected to enter the market for 60 locomotives.

The Ferrocarril de Pacifico of Columbia, S. American has ordered 10 locomotives of the 4-8-0 type from the Baldwin Locomotive Works.

Freight Cars

The Northern Pacific Railway has in operation a freight car repair and construction for the company's shops which calls for new underframing for about 2,500 cars and the construction of 1,000 box cars and 150 flat cars each year.

The Northern Pacific Railway contemplates repairing from 500 to 1,000 box cars. This company has also ordered 200 flat car underframes from the Siems-Stemble Company.

The Carnegie Steel Company is inquiring for four flat cars of 70 tons' capacity.

The Chicago, South Shore & South Bend has ordered 4 thirty-foot, steel underframe caboose cars, from the American Car & Foundry Company.

The Otis Steel Company has ordered three 30-yard extension side dump cars from the Clark Car Company.

The Chicago, St. Paul, Minneapolis & Omaha Railway is in the market for 250 all steel general service cars, of 50 tons capacity.

The American Steel & Wire Company has ordered 20 side dump cars from the Clark Car Company.

The Central Alloy Steel Company, Massillon, Ohio, has ordered an air dump car, from the Koppel Industrial Car & Equipment Co.

The Solvay Process Company has ordered 35 tank cars from the American Car & Foundry Company.

The St. Louis Southwestern Railway has ordered 10 steel underframes for box cars from the American Car & Foundry Co.

The Chicago, St. Paul, Minneapolis & Omaha Railway is inquiring for 500 hopper car bodies.

The United States Smelting & Refining Co., is in the market for from 12 to 16 general service cars of 70 tons' capacity.

H. W. Taylor, Hagerstown, Md., has ordered 4 air dump cars from the Koppel Industrial Car & Equipment Co.

Passenger Cars

The Seaboard Air Line is having two gas-electric rail motor cars and two trailer coaches built at the plant of the St. Louis Car Company: The motor cars are to be equipped with Electro-Motive Company power plants.

The Boston & Maine Railroad has ordered the necessary material for converting one mechanical gasoline rail motor car to a gas-electric, from the J. G. Brill Company.

The Chicago, Burlington & Quincy Railroad is making inquiry for 26 gas-electric cars.

The Chicago, Milwaukee & St. Paul Railway is inquiring for 10 baggage cars.

The Newfoundland Railway is in the market for one combination sleeping and observation car and two sleeping cars.

The Pacific Electric Railway contemplates buying new passenger car equipment including 10 light interurban cars.

The Chicago North Shore & Milwaukee Railroad has ordered 15 coaches, 1 parlor car and 2 dining cars from the Pullman Car & Manufacturing Corporation.

The Georgia & Florida Railway is inquiring for passenger equipment including 8 coaches and 7 combination passenger, baggage and mail cars.

Buildings and Structures

The Canadian National Railway has contracted for the construction of a 100-ton mechanical coaling station at Moose Jaw, Sask., and the contract has been let to the Bennet and White Construction Company, Calgary, Alta. A contract for the construction of a similar mechanical coaling station at Camrose, Alta., has been let to H. G. Macdonald & Co., Edmonton, Alta.

The Boston & Albany Railroad has awarded contracts to the Milwaukee Electric Crane & Hoist Company for two 10-ton gantry cranes.

The Boston & Maine Railroad has ordered from the Union Switch & Signal Company 19 complete locomotive equipments for use on engines operating over the territory between Boston and Greenfield. The Boston & Maine has also ordered material for the complete installation of an electro-pneumatic interlocking at Tower "H," Somerville, Mass.

The Missouri-Kansas-Texas Lines has awarded a contract for the construction of a one-story forge and blacksmith shop and a one-story wood-working shop at Muskogee, Okla., has been awarded to the Austin Brothers Construction Company, Austin, Tex.

The Texas & Pacific Railway has awarded a contract to the Austin Brothers Construction Company, Austin, Tex., for the construction of a steel shop building at Big Spring, Tex. Outside dimensions of the shop will be 42 ft. by 146 ft. with an addition of 14 ft. by 62 ft.

The Tennessee Central Railway has placed an order for a junior "N. W." type electrically operated cinder conveyor to be installed by company forces at Monterey, Tenn., which has been given to the Roberts and Schaefer Company, Chicago. This project will include the construction of two inspection pits.

The Missouri Pacific Railway has awarded a contract to Fairbanks, Morse & Co., Chicago, for the construction of a 400-ton reinforced concrete mechanically operated coaling station at Gurdon, Ark.

Supply Trade Notes

A. H. Deimel has joined the New York office of the **Buda**

Company, and will travel the eastern territory as a sales engineer.

Charles A. Perryman, former Sales Manager of the Wire Rope Department of the **Wickwire Spencer Company, Inc.**, is now associated with the **American Cable Company**, makers of the preformed "Tru-Lay" type of wire rope, in the capacity of Assistant Sales Manager.

J. R. Matlack, treasurer of **S. F. Bowser & Company**, Ft. Wayne, Ind., has been appointed treasurer and general manager of the **S. F. Bowser & Company, Ltd.**, Toronto, Ont., and will be succeeded by **E. D. Eggimann**, the secretary.

F. H. Clark, Consulting Engineer, announces the opening of his office at 949 Broadway, New York and is prepared to make examinations and reports on railway and allied industrial problems and undertakings.

His earlier experience included sixteen years service in the Motive Power Department of the Chicago, Burlington & Quincy Railroad, six of which were in the position of General Superintendent of Motive Power. This was followed by eight years service on the Baltimore & Ohio Railroad. Seven years have since been spent as Technical Adviser to the Ministry of Communications of the Republic of China, on standardization of equipment and on various questions of railway engineering and operation.

Morse Twist Drill & Machine Company, New Bedford, Mass., has opened a store at 92 Lafayette Street, New York where they have put in a complete stock of their products consisting of high speed and carbon drills, cutters, reamers, taps, dies, etc., for the convenience of their distributors, dealers and users.

Jack L. Jacobson has been appointed representative in the New York territory of the **Reading Iron Company**, Reading, Pa. Mr. Jacobson was formerly associated with the **Barrett Company**, of Chicago, Ill.

The Alexander Milburn Company, 1416-1428 West Baltimore Street, Baltimore, Maryland, manufacturers of Welding and Cutting Apparatus, Portable Carbide Lights, Oil Burners and Preheaters, and Paint and Lacquer Spraying Equipment has organized an office in Boston to be known as The Alexander Milburn Sales Company, Wiggin Terminals Building, 50 Terminal Street, Boston, Mass.

This office is under the supervision of Messrs. M. B. Crouse and G. B. Malone, both experienced executives in welding and cutting equipment. This office will handle the sale and distribution of Milburn Equipment throughout the New England States in a highly specialized manner.

William H. Croft, vice-president and director of the **Magnus Company, Inc.**, Chicago, has been elected a director of the **National Lead Company.**

The Northern Engineering Works, main office and factory at Detroit, have recently added to their line of cranes and hoists a new series of Hi-Lift Hoists which, in both design and construction, as well as operation, is a distinct stride forward in this field.

The new Hi-Lift is of compact design, rigid construction and besides ready accessibility and high efficiency in operation it features an exceptionally high hook lift, the advantages of which are appreciated by all users of such equipment especially those manufacturers having plants with low ceilings.

Items of Personal Interest

W. W. Payne has been appointed road foreman of engines of the Seaboard Air Line at Savannah, Ga., succeeding **A. E. Hopkins**, deceased.

H. H. Hummel has been appointed assistant to the general superintendent of motive power of the Southern Pacific System with headquarters at San Francisco, Cal.

F. C. Smith has been appointed master mechanic of the Florida East Coast Railway at Miami, Fla.

F. H. Graf has been appointed acting air brake foreman of the Atchison, Topeka & Santa Fe at San Bernardino, Cal., in place of **William Allen**, who has been granted a leave of absence on account of illness.

A. J. Poole has been appointed mechanical assistant of the Tennessee Central Railroad with headquarters at Nashville, Tenn.

W. T. Abington, master mechanic of the Missouri Pacific at McGehee, Ark., has been transferred to the Southern Kansas division with headquarters at Coffeyville, Kans. He succeeds **C. R. Kilbury** who has been transferred to the Omaha and Northern Kansas divisions with headquarters at Falls City, Neb., and **G. T. Callender** has been transferred to the Eastern division, with headquarters at Jefferson City, Mo., succeeding **D. W. Cunningham** who has resigned.

Ralph W. Anderson has been appointed general superintendent of motive power of the Chicago, Milwaukee & St. Paul Railway at Milwaukee, Wisc., succeeding L. K. Sillcox who resigned. For the past seven years Mr. Anderson was superintendent of motive power of the Eastern lines of the road until his recent appointment with jurisdiction over the entire system.

W. W. Wickline has been made road foreman of engines of the Chesapeake & Ohio Railroad at Rainelle, W. Va., succeeding **A. H. Simmons.**

W. W. Moore has been appointed supervisor of motor car operation of the Seaboard Air Line with headquarters at Raleigh, N. C.

A. H. Whittaker, who has been general foreman locomotive department of the Seaboard Air Line at Portsmouth, Va., has been promoted and is now master mechanic of the West Florida division with headquarters at St. Petersburg, Fla.

H. C. Quarles has been appointed master mechanic of the Seaboard Air Line at Arcadia, Fla., succeeding **F. S. Markett**, resigned.

G. P. Trachta, master mechanic of the Chicago, Burlington & Quincy Railway with headquarters at Omaha, Neb., has been transferred to the Galesburg, division with headquarters at Galesburg, Ill.

W. G. Chandler formerly master mechanic of the Canadian Pacific Railway at Schreiber, Ont., Can., has been appointed division master mechanic at Chapleau, Ontario, succeeding **J. H. Brooks**, who has retired.

A. E. Buckland who has been locomotive foreman of the Canadian Pacific Railway at McTier, Ontario has been transferred in the same capacity to Lambton, Toronto, where he succeeds **C. S. Burns**, who has been transferred to West Toronto.

Lewis K. Sillcox, who resigned as general superintendent of motive power of the Chicago, Milwaukee & St. Paul has been appointed assistant to the President of the New York Air Brake Company, with headquarters at New York. Mr. Sillcox entered railway service in July, 1903, as a roundhouse apprentice on the New York Central & Hudson River (now the New York Central) at High Bridge, N. Y. In 1909 he was appointed shop engineer of the Canadian Car & Foundry Co., Montreal, Que., where he remained until 1912 when he returned to railway service as mechanical engineer of the Canadian Northern. Mr. Sillcox was appointed mechanical engineer of the Illinois Central, at Chicago, in 1916 and later became master car builder of the Milwaukee, with headquarters at Milwaukee, Wis. In 1920, he was promoted to assistant general superintendent of motive power, with headquarters at Chicago, and two months later he was again promoted to general superintendent of motive power, a position held continuously until his resignation and appointment as assistant to the president of the New York Air Brake Company. Mr. Sillcox resigned as chairman of the Mechanical Division of the American Railway Association and from all committees of which he was a member.

Llewellyn Jehu Railway, assistant foreman, Motive Power Department, Point St. Charles shops, Canadian National, Montreal, Que., Can., has retired on pension after having been in the company's service and that of its predecessors for 55 years.

Obituary

Edward Turner Jeffery, former president and chairman of the board of directors of the Denver & Rio Grande and the Western Pacific Railways died in New York on September 24. Mr. Jeffery was born in Liverpool, Eng., on April 6, 1843, and entered railway service in October, 1856, at the age of 13 years, as an office boy for the superintendent of machinery of the Illinois Central at Chicago. From December of the same year until February, 1871, Mr. Jeffery served successively as an apprentice in the Chicago shops, as an office boy, as an apprentice in the office of the mechanical draftsman, as a mechanical draftsman and as secretary to the superintendent and chief engineer of the Illinois Central on May 4, 1877. Eight years later Mr. Jeffery was promoted to general manager. In October he was elected president of what is now the Denver & Rio Grande Western, serving until January, 1912. He was also president of the Western Pacific Railroad from June, 1905 to July, 1913, when he was elected chairman of the board of directors. In January, 1912, Mr. Jeffery relinquished the presidency of the D. & R. G. to become chairman of the board of directors, a position he held along with the chairmanship of the board of the W. P., until his retirement in January, 1917.

Joseph C. Schepp, master mechanic on the Texas & Pacific Railway with headquarters at Texarkana, Tex., from 1914 to 1917, died at Ft. Wayne, Ind., on September 26. Prior to 1914 he had been general foreman of shops of the T. & P. at Marshall, Texas.

New Publications

Books, Bulletins, Catalogues, etc.

Freight Train Resistance on a One-Degree Curve and on a Three-Degree Curve by Edward C. Schmidt is the title of bulletin No. 167 which has just been issued from the Engineering Experiment Station of the University of Illinois presents the results of tests made with five freight trains in order to find the excess of their resistance on curved track over that on straight track. This excess, termed curve resistance, was determined on a one-degree curve and a three-degree curve. On each curve tests were made with each train at three speeds, namely, 10, 20, and 30 miles per hour. Track of fair construction, laid with 70-pound rails, was used. The average gross weight of the cars composing the test train varied from 15.1 to 48.6 tons. The tests were run during warm weather, and all but seven of the tests were made when wheels and rails were dry.

From the results obtained it was found that the general average curve resistance, disregarding speed distinction, was practically the same on the two curves. With one exception, the average results for all trains showed, on both curves, a decrease in curve resistance as the speed was increased. The rate of decrease, however, was not great, nor was it uniform. The few tests run on wet rails gave evidence that curve resistance was diminished when rails and wheels were wet.

It is believed that the results obtained may safely be applied to predict the curve resistance of all freight trains, running on either good or poor track, and under either summer or winter temperatures. It is not certain whether the results are applicable to track curvatures much in excess of three degrees.

Copies of Bulletin No. 167 may be obtained without charge by addressing the Engineering Experiment Station, Urbana, Illinois.

The Railway Year Book. Railway Publishing Co., Ltd., 33, Tothill Street, London, S. W. 1, England.

The Railway Year Book has been published annually for a period of 30 years and may therefore be regarded as direct evidence that it supplies a definite demand. It presents a great deal of information in regard to the British railways, much of which would otherwise have to be extracted from a wide field of literature. Many of the most important statistics cover the year of 1926, such information not being otherwise available until late in the year of 1927.

The present edition retains all usual features, revised as necessary and in some cases extensively. Owing to the fact that train service developments were impracticable last year, due to the general strike and the coal dispute in Britain, the tables of long-distance non-stop runs and fastest runs, and of restaurant-car facilities, slip coach, and sleeping-car services, etc., are the same as appeared in the issue for 1925. They are thus available for reference as showing the facilities which the British railway companies normally provide and upon which developments, anticipated during the following year, will be based. The "Who's Who" section includes a number of new biographies, and covers the numerous official changes which have occurred since the 1926 edition was published.

Nickel in the Brass Foundry is the title of a bulletin recently published by the International Nickel Company, 67 Wall St., New York, which gives an interesting account of some of the applications of nickel in foundry work, such as in bearing composition, casting compositions and gear bronzes, etc., which shows that this metal insures higher strength, better wearing properties and decreased surface pitting, in addition to permanent beauty.

American Multiple Throttle. The American Throttle Company, 17 East 42nd St., New York has issued Bulletin No. 2, which describes the operation and maintenance, and illustrates a typical application, of the American multiple throttle, more than six hundred of which are now in service on railroads throughout the United States and Canada. The company also has placed the same information in the form of a wall chart, which is suitable for use in shops and roundhouses.

Spiral Lowering Chutes. The Roberts & Schaefer Company, Chicago, has issued Bulletin No. 94, describing and illustrating its spiral lowering chutes, which have been designed to minimize the breakage and segregation of lump coal when being placed in locomotive coaling plants.

Garratt Type Locomotives. Messrs. Beyer, Peacock & Co., Ltd., Manchester, England, have issued an artistic thirty-six page publication to illustrate the latest examples of their Garratt type articulated locomotives. The cover depicts in the color one of the London, Midland & Scottish Railway's Garratts with a typical Scotch landscape. The designs shown have tractive powers ranging from 15,880 lb. for the South African Railways, 2 ft. gauge to 69,150 lb. for the Nitrate Railway of Chili, 4 ft. 8½ in. gauge, at 75 per cent of the boiler pressure. Beneath each illustration in addition to the leading dimensions, is an interesting account of the duties and results in actual service of the engine dealt with. At the end of the booklet are a series of photographic reproductions showing the Garratt engine at work in the Argentine, Burma, West Africa, North West India, Chili, Rhodesia, Sierra Leone and on the South African Railways, as well as some of the British Railways.

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

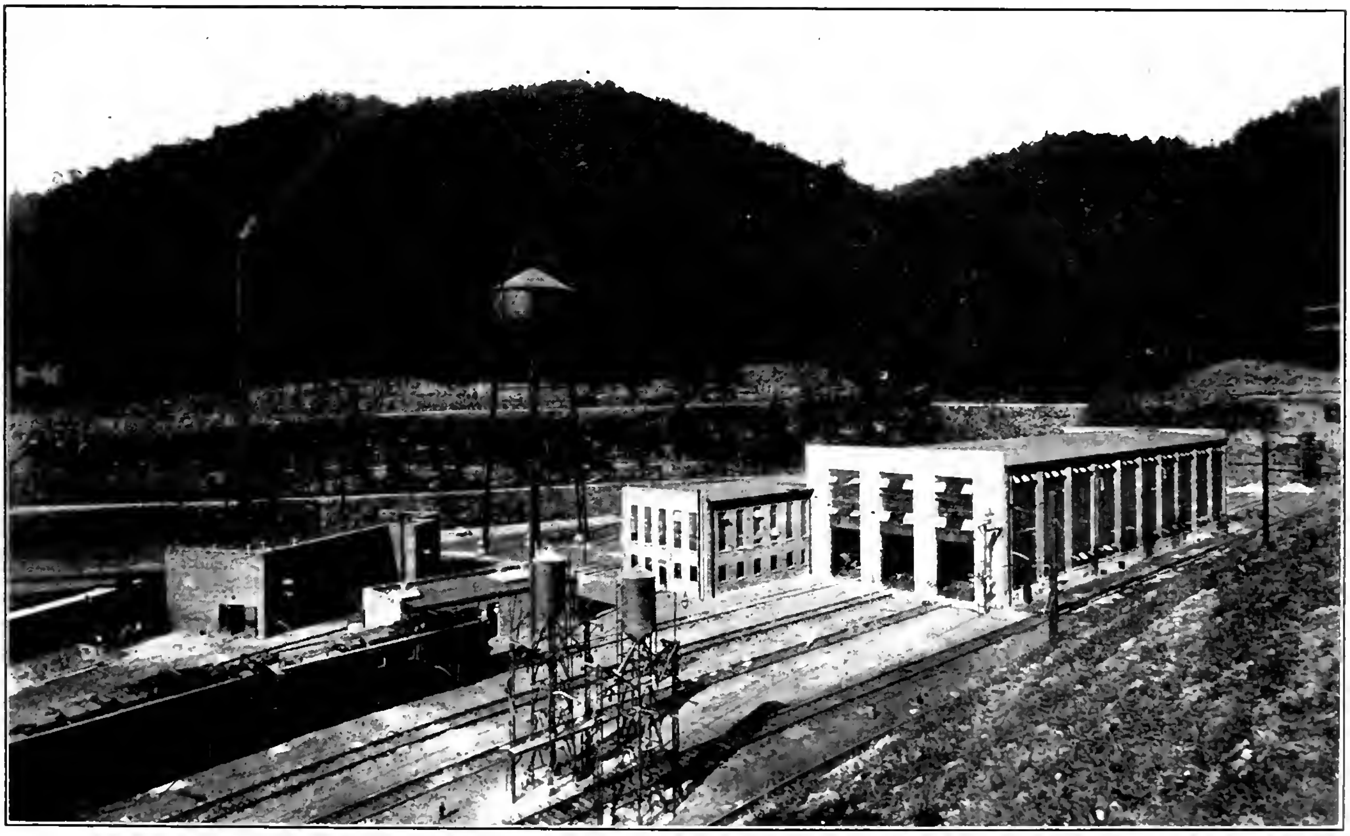
Vol. XL 136 Liberty Street, New York, November, 1927 No. 11

Electric Locomotive Maintenance Shop of the Virginian

Electric Locomotive Repair Shop of the Virginian Railway at Mullens, West Virginia

By Allen McLanahan, Service Engineer, Westinghouse Electric & Manufacturing Company

In connection with the electrification of 134 route miles of track from Mullens, W. Va., to Roanoke, Va., complete service on which was inaugurated in 1926, the Virginian Railway erected a new modern shop for the maintenance and repair of electric locomotives. As this is one of the few instances that a complete new plant, designed for the purpose, has been constructed in connection with an electrification, it is believed that a description of the whole arrangement will be of interest.



General View of the Virginian Railway Electric Locomotive Maintenance Shop

It will be recalled that this fifteen million dollar electrification, contract for which was awarded to the Westinghouse Company in 1923, included 36 motive power units of 215 tons each. Normally three units comprise a locomotive so that shop facilities had to be provided to care for locomotives measuring over 150 ft. in length.

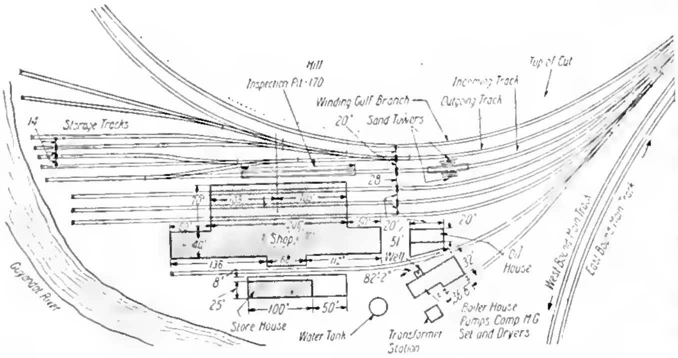
In considering the proper location for the electric shop it was desired that it should be not only the repair point, but as far as possible should be the turning point for all locomotives. Since the service requires that certain locomotives operate only at the western end of the electrification, on Clark's Gap Hill, the shop was located at Mullens, which is the western end of the electrified zone. All engines now operate out of Mullens and the necessity of maintaining a stock of spare parts at several points is eliminated. With this location the only additional shop facilities required are those for making the inspection and running repairs to locomotives at Roanoke after their eastbound trip.

General Shop Layout

From the accompanying plan layout it will be seen that the plant includes the shop proper, a storehouse, an oil house, a building for the substation and steam heating boiler, a water tank, sanding towers, an outside inspection pit and locomotive storage tracks. As all the tracks outside the shop was electrified, there is no need for a steam locomotive to move the electric locomotives.

On arrival from the road a locomotive passes between the sand towers, where the sand boxes and rheostat fresh water tanks are filled and the running gear washed. After this is completed it is moved on the same track to the inspection pit, where it receives a complete mechanical and electrical inspection. The trolley wire over this pit is equipped with a disconnecting and grounding switch so that the inspection of the pantagraphs and roofs can be made in perfect safety. After inspection the locomotive is put on one of the storage tracks until it is again called. If repairs are to be made, the locomotive is pushed into the shop by another electric locomotive.

The water for shop purposes and for use in the liquid rheostats is obtained from a well located under the substation building. A deep well pump supplies this water to the 125,000 gallon storage tank from which it is piped to the shop and yard. For fire protection a motor driven fire pump supplies water at high pressure to a pipe line to which fire hydrants are connected at convenient points in the shop yard.



Plan of General Layout of Virginian Railway Locomotive Inspection Shop

The Main Shop

The main shop building has two bays and one wing which contains the carpenter shop, bake ovens and dip tank.

The first bay or inspection building is 206 ft. long and 70 ft. wide and contains three pit tracks, long enough to take care of a complete locomotive. These pits have a jacking shelf and are equipped with permanent lights as well as receptacles for portable lamps and are piped for compressed air. There is a drop pit near each end of these tracks so that six points have been provided for dropping wheels and engine trucks. The drop pits are equipped with portable hydraulic jacks. This bay is served by a 30-ton electric crane. A gallery has been provided along the outside track at the height of a locomotive roof for use in connection with pantagraph or other roof work.

The second bay contains the tool room, air brake room, machine and blacksmith shops, winding room, electrical repair spaces, locker and washrooms and the offices. This bay is served by a 15-ton electric crane, operated from the floor.

The floor of the whole shop consists of two-inch treated oak planks laid on sills set in crusher dust. The shop is heated by an indirect system of unit heaters, each unit consisting of a steam radiator, electric blower fan and air piping. The ceiling is painted white and an ample provision of lights results in excellent illumination at night in all parts of the shop.

The whole shop is piped for compressed air and outlets are located at convenient points for connecting portable lamps, the insulation testing outfit and a portable arc welding set. In addition there is a 32-volt a-c. circuit, by means of which current can be supplied to the locomotive lights without the necessity of using the batteries or energizing the locomotive. This arrangement is of great assistance in working inside the locomotive cabs as it obviates the necessity of taking portables into the cabs.

Interior View of Virginian Railway Shop Showing Drop Pits

The machine shop contains the following machine tools, all of which have individual motor drive:

84 in. Engine lathe
30 in. Engine lathe
24 in. Engine lathe
18 in. Engine lathe
60 in. Universal (Horizontal) boring mill
48 in. Vertical turret lathe
32 in. Crank planer with 40 in. stroke
40 in. Shaper.
32 in. Crank planer with 40 in. stroke
36 in. Radial drill press
28 in. Vertical drill press
18 in. Vertical drill press
Bolt Machine
4 in. Pipe cutting machine

In addition there are two electric grinders, a 100-ton air operated bushing press and hand operated sheet metal shears, roller and crimper.

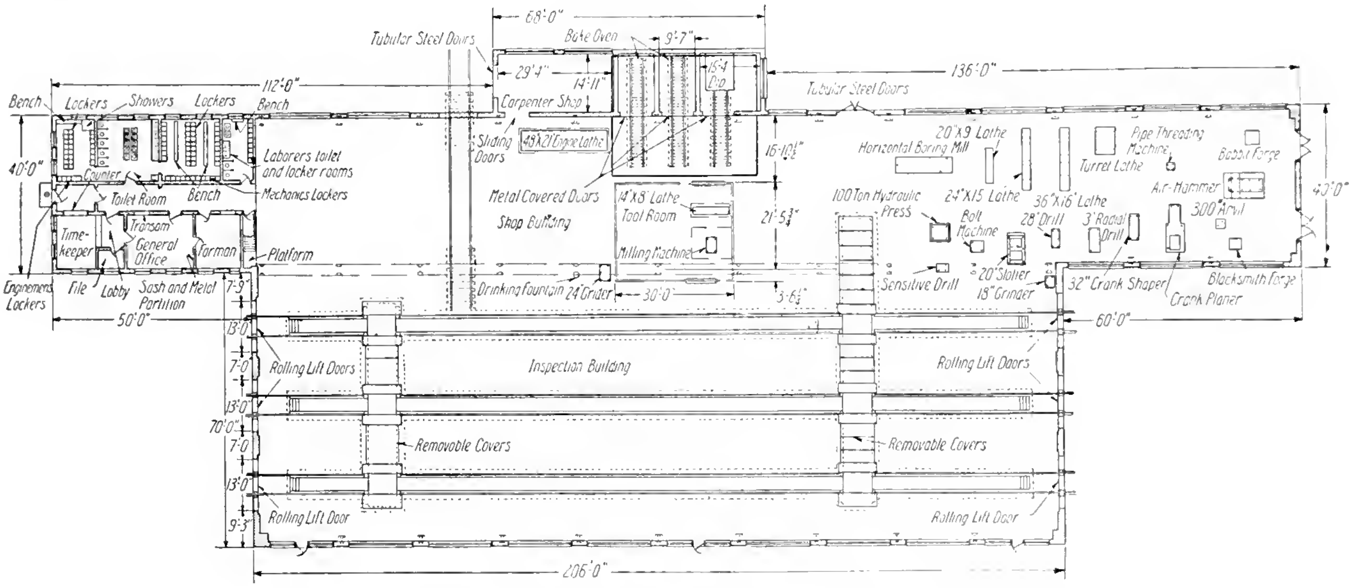
No tire turning equipment or wheel press has been installed as it is intended that this work shall be done in the Princeton shops.

The 84-in. lathe is used for banding the large traction motor and phase converter rotors and can be used for turning the journals of the driving wheels if necessary.

The tool room, located in the center of the shop, is equipped with the necessary shelves for tools and special equipment and contains a 14-in. engine lathe and a universal milling machine. The carpenter shop has a combination woodworking machine, which consists of band saw, planer, rip saw and wood lathe.

In the blacksmith shop are two forges, one of which is used for babbitting work. These are supplied with air from a special motor driven blower. For heavy work there is a 600-lb. air operated hammer, the air being supplied by a motor driven compressor which is integral with the hammer. An electric pyrometer is used in connection with the babbitting furnace to insure that the babbitt is poured at the proper temperature.

A separate room enclosed by a wire screen is used for the repair and testing of the air equipment. This room is furnished with benches, a test rack designed for testing the air brake equipment used on the locomotives and a special rack for testing magnet valves.



Plan of Layout of Inspection Building of Virginian Railway Locomotive Inspection Shop

On the ground floor offices are provided for the timekeeper and crew dispatcher, the general foreman and the electrical foreman. The washroom and toilet facilities are located across the hall from the offices and there are three locker rooms for enginemen, white shopmen and colored shopmen. A shower bath is installed in the enginemen's locker room.

A gallery above the offices and locker rooms is used for the repair of the light electrical equipment of the locomotives, such as switches, magnet valves, relays and brushholders. Compressed air at 70 lb. pressure, as used in the control of the locomotives, is available at all of the benches.

A separate room is provided for repairs to delicate relays and meters. This is equipped with a test table from which the various low currents and voltages for use in calibrating these instruments may be obtained. It is intended that in addition to the locomotive meters the meters and relays from the substations and power plant shall be repaired here. The gallery also contains a room which is used both as an office for the road foreman of engines and an instruction room for enginemen.

Two independent ovens especially designed for this purpose by the Westinghouse Electric & Manufacturing Company are provided for drying and baking the electrical apparatus. They are built of heat insulating material and are heated by electric heaters. There is a chamber above each oven equipped with a ventilating fan and dampers in order to provide a circulation of air through the oven during the drying. This has been found to materially assist in this process.

The temperature of the oven is automatically maintained between desired limits by means of a thermostat which operates the control of the electric heaters, and current is automatically cut off whenever the oven doors are opened. A record of the temperature is kept by Bristol recording thermometers. A voltmeter and necessary connections are provided for measuring the insulation resistances of the pieces of apparatus which are being dried out without opening the oven doors. These ovens, together with the dip tank are located in a wing of the main shop.

In laying out the arrangement of the dip tank particular care was taken to minimize the risk from fire, due to the highly inflammable character of the insulating varnish used for this purpose. The tank is located in a separate room, provided with fireproof doors and a ventilating fan to exhaust the vapor into the outside air. An emergency tank of the same capacity as the dip tank is buried below the latter. In case of fire a valve may be opened from the outside which will allow the varnish to flow by gravity into the emergency tank and thus extinguish the fire. Connections are made to this tank so that the varnish may be raised again to the dip tank by air pressure. The dip tank is also provided with a lid which will automatically close by gravity in case of fire.

Storehouse and Oilhouse

The storehouse building is 25 ft. by 100 ft. and has a large platform for unloading material and for the storage of castings and other material which does not require protection from the weather. The interior of the house is fitted with steel shelves for the storage of the various spare parts of the locomotives and other necessary material. It also contains an electrically operated water still which supplies all the distilled water required on the road.

The oil house is a separate building with a large platform for barrels and boxes of grease. It is fitted with tanks for oils of which small quantities are used and has measuring pumps connected to the underground tanks in which the large amounts of oil are kept. An air operated press for forming drive journal grease cakes and the grease sticks used in the main rods and for hubliner lubrication is located here. A separate room at one end of this building is fitted up as a supply room where lanterns, flags, engineer's tool boxes and other locomotive supplies are kept.

Electric Substation

Two Westinghouse 200-kw., 250-volt, single-phase synchronous motor generator sets supply the 250-volt direct current for operating all the shop machinery and the lights. The power for driving these sets is obtained from the 11,000-volt trolley wires and the voltage is stepped down by two transformers, one for each machine, located in an outdoor substation. The sets are started by single-phase series motors, mounted on the common shaft, the transformers being arranged to give the reduced voltages required for this purpose. Disconnecting switches are provided so that the transformers may be supplied from either the eastbound or westbound trolley in order to provide for continuity of service.

The switchboard contains the following panels: 2 a-c. motor, 2 d-c. generator and 3 d-c. feeder panels. The d-c. feeder lines run to distribution panels in the shop where the fuses and switches for the various motors and lighting circuits are located.

The substation room also contains a single stage, 12x10 air compressor which provides the compressed air for shop purposes. An emergency connection is provided for connecting locomotive compressors to the shop air system in case of breakdown of the shop compressor.

Special Features

As the transformers used on the locomotives are of the oil insulated type, arrangements have been made for the purification of this oil. These consist of an oil treating outfit, located in the substation room, two oil tanks buried in the ground and pipe lines to the shop. There are two of these lines, one for the clean and one for the dirty oil, each with three outlets on each side of the shop, properly spaced to take care of a 3-unit locomotive. By means of a manifold and valves the dirty oil can be run down into one of the tanks and fresh oil pumped into the transformer, or the oil can be taken out through the filter into a tank and then passed through the filter again into the transformer. By this system the oil of all the transformers of a 3-unit locomotive can be completely purified in one day. This piping is also arranged so that the oil in the substation transformers can be passed through the same filter if desired. Two additional tanks, with the necessary piping, have been provided to purify the oil used in the circuit breakers without mixing it with the transformer oil.

One end of the substation building is used for sand storage and drying, a coal stove being used for the latter purpose. The dry sand is put into one of two drums, each connected to one of the sanding towers, and raised to the towers by admitting air to the top of the drum. The two sanding towers are located one on each side of the incoming track. Each tower has three outlet pipes, spaced to accord with the openings of the locomotive sand boxes. This enables a unit to be completely sanded without movement. As the sand box openings are on the outside of the cabs, no sand enters the equipment compartment.

Among the new features in this shop are the two portable electric pinion heaters, made by the Westinghouse Company. These are of the induction type, being really the primary of a transformer, the pinion itself being used as the secondary and being heated by the current which passes through it. By the use of these heaters the locomotive pinions are heated more rapidly and uniformly than is possible in an oven, about 35 minutes being required to raise the temperature to 135 degrees Centigrade, which is the temperature at which the pinions are applied to the traction motor shafts. While these heaters were primarily designed for pinions, they are used for heating bushings and other rings which are to be shrunk on.

The policy of using special tools and mandrels wherever desirable has been followed from the beginning, a large supply of these being obtained with the locomotives. Since that time additional tools have been made as soon as they were seen to be of advantage.

Since the shop has been in full operation the layout has been found to completely meet the requirements. It is believed that this plant, especially designed for the upkeep of the Virginian locomotives will be an important factor in holding the maintenance costs to a minimum.

The requirements on the Virginian Railway are so severe that each electric locomotive is composed of three motive power units, totaling 7125 horse power, which are arranged with all of the necessary provision for future operation of four units as one locomotive if required. The whole plan and design of the new electric locomotive maintenance shop of the Virginian Railway has been laid down with the view of future expansion to take care of additional units over present equipment if necessary.

Railroad Investment and Capitalization

The investment of the railroads exceeds their net capitalization outstanding in the hands of the public at the present time by more than four billion dollars.

This fact is brought out statistically in reports recently furnished by the Interstate Commerce Commission.

The Commission's figures show that the net capitalization of all the railroads, with the exception of switching and terminal companies, was in round numbers, 18 billion 200 million dollars in the year 1925. By "net capitalization" is meant the total amount of railway securities, stocks and bonds outstanding in the hands of the public. The railway securities held by railways are not included.

The following figures review the net capitalization of the American steam railways for recent years:

Year	*Capital stock*	*Funded debt*	*Total capital*
1911	$5,874,783,419	$ 9,169,699,475	$15,044,482,894
1916	6,415,953,044	9,916,615,284	16,332,568,328
1920	6,706,530,562	10,287,399,701	16,993,930,263
1921	6,673,423,777	10,409,452,216	17,082,875,993
1922	6,751,349,854	10,528,376,315	17,279,726,169
1923	6,847,048,512	10,963,213,750	17,810,262,262
1924	6,805,830,355	11,396,067,357	18,201,897,712
1925	6,885,437,186	11,305,076,143	18,190,513,329

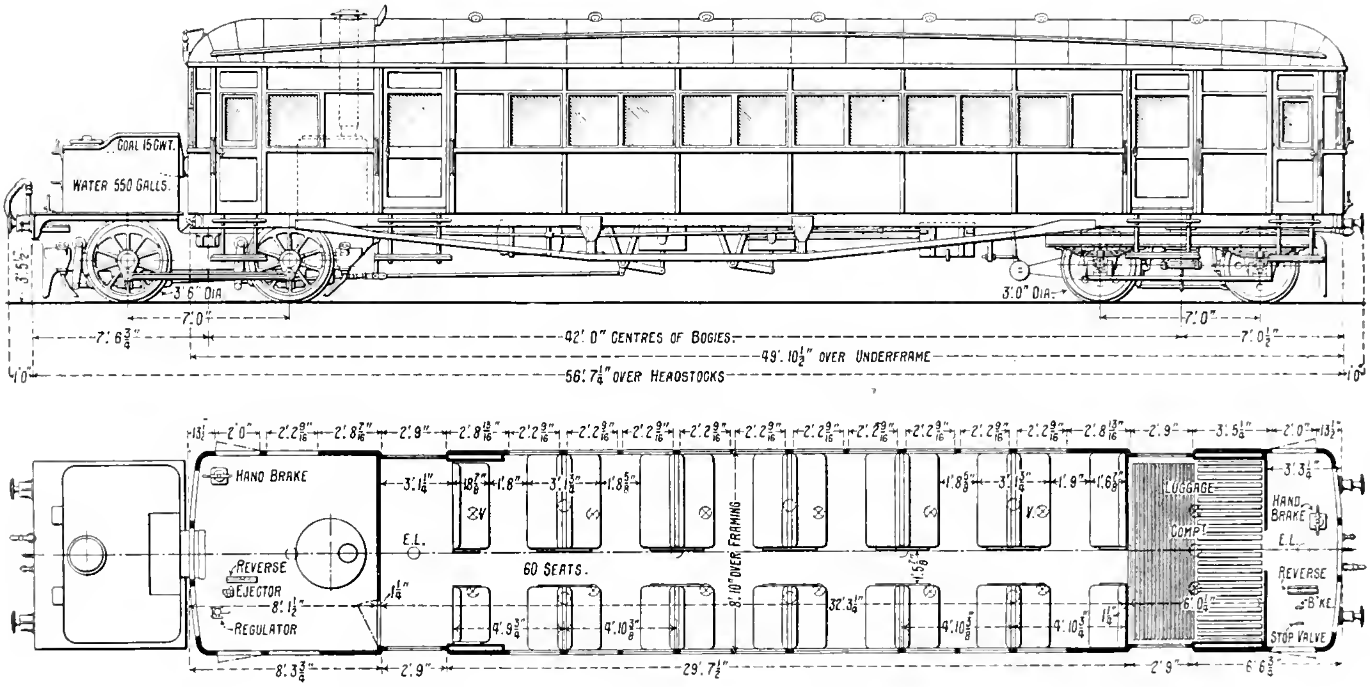
In the language of the Interstate Commerce Commission, "$18,190,513,329, or $74,460 per mile of road, is the net sum which would be necessary to purchase these railways, considered as one system, on the basis of the par value of their stocks and bonds not held under railway ownership."

The investment in road and equipment, on December 31, 1925, of the roads covered in the foregoing table, amounted to $22,736,993,054, a total more than four billion dollars greater than their net capitalization. In days gone by, the cry of "watered stock" used to be raised against the railways, the claim being made that railway capitalization was in excess of railway investment. This may have been true at one time (although the figures of the Interstate Commerce Commission, which extend back as far as 1890, do not support such a claim), but now, when investment exceeds net capitalization by over four billion dollars, there is no longer any basis for this charge.

A New Design of Steam Railway Motor Car

Light Power Units for Railway Service Built by Clayton Wagons, Ltd. of England for London and North Eastern and the Egyptian State Railways.

It has become increasingly necessary to utilize varied forms of traction and employ types of vehicles adaptable for meeting specialized conditions as represented in the development in rail motor cars in this country, where such cars are generally driven by internal combustion engines because of the present comparative cost of oil fuel as against coal. In England, however, the efficiency of small steam boilers and engines for use on steam road cars has been developed to meet the competition of automobiles. The latest designs of steam cars are claimd to be a most economical and reliable means of transporting heavy loads by road.



Elevation and Plan of Clayton Steam Rail Car Undergoing Trials on the London North Eastern Railway

Wherever road motor vehicles are operating in passenger or freight service in competition with the railway, the steam car offers a more economical type of vehicle than the ordinary locomotive and train, particularly on branch lines or wherever the motor truck may be operating to the disadvantage of the railway.

One of the advantages of the steam-operated car is that those called upon to handle it are already accustomed to driving steam units, and little or no special training is necessary. The features most strongly desirable in a steam rail car may be summarized as follows:

(1) Economy in fuel, oil, and water consumption.

(2) Simplicity in operating and ability to be driven from either end to avoid the necessity for reversal at terminals.

(3) Reliability.

(4) Conformity to standard coupling heights, type profiles, etc., and ability to make use of standard watering and coaling appliances.

(5) Economy in mechanical maintenance.

(6) Smoothness of running at all speeds.

(7) Comfort in seating and adequate lighting and ventilation.

(8) Capacity to maintain existing running times.

(9) Reasonable cost.

In England the design and construction of rail motor cars has largely passed into the hands of engineering firms who have specialized in internal combustion and steam cars. Several designs have thus been produced which may be depended upon for reliability, efficiency and economical operation. The introduction of such cars has in more than one case converted serious revenue losses (due to traffic falling off in face of motor bus competition) into substantial gains, much of the traffic being recovered, or new traffic attracted and created, owing to the popularity of the steam rail cars with the traveling public.

The modern steam rail car, as built by those British firms who have specialized in it, may be said to meet most, if not all, of the above conditions in admirable fashion, and from some long experience of the design and operation of these vehicles they seem to have a big future before them.

Details of the Clayton Steam Cars

In the Clayton steam rail cars the engine has two double-acting cylinders, each 6¾-in. diam. with a stroke of 10 in. Steam distribution is effected by piston valves operated by eccentrics mounted on a layshaft. The eccentrics work in the crankcase oil bath, and are, therefore, perfectly lubricated. A simple device is used to control the angle of advance and throw of the eccentrics so that a full range of cut-off from zero to maximum is under the control of the operator. By the same means the eccentrics are brought into the reverse position. The engine is balanced by means of weights secured to the crank webs. The crankshaft is provided with a roller bearing at the driving-pinion end, and a self-aligning ball bearing at the opposite end. Separate glands are provided for the piston rods and valve rods at the cylinder end and the crank-case end to prevent leakage of steam into the crankcase and loss of oil. All the working parts of the engine are totally enclosed and dirt and dust are effectively excluded. The cylinders are lubricated by a Detroit lubricator, fitted in the driver's cab in a fully visible position. Crankshaft revolutions from 150 to 450 per minute are equivalent to car speeds of 15 to 45 m. p. h., respectively.

The boiler is of the vertical type with water tubes and superheating coil, and supplies steam to the engine at a pressure of 275 lb. per sq. in. With feed water at a temperature of about 200 deg. F. and coal of a calorific value of 14,500 B. T. U., the boiler will evaporate 1,850 lb. of water per hour continuously. The boiler is fired from the top through a stoking chute. The furnace with tubes can be dropped for examination, or for cleaning, by removing the nuts on the foundation rings. The joint faces are machined and fitted with asbestos gaskets. Two feed-water systems are provided, a steam-driven pump and an injector. A feed-water heater is provided in the exhaust pipe line.

Transmission Details

A pinion is mounted on the engine crankshaft and meshes with a spur wheel mounted on the axle. These gears are of forged steel with machine-cut teeth. They run in an oil bath, and are totally enclosed. This method of driving has been adopted as being very satisfactory for railway service. The reliability and robustness of this drive is attested by its universal use in electric traction. The crankcase of the engine is mounted on the axle on white-metalled gunmetal bearings, and these bearings are pad-lubricated. The engine is additionally suspended by a link from a cross bearer of the truck frame. With this type of drive, starting and acceleration are effected smoothly and progressively, and the possibility of loss of adhesion and slipping which is present with the usual type of locomotive drive is greatly reduced. The driving truck axles are provided with bronze axle-boxes with white metal inserts of standard design, and are coupled by side rods. The wheels and axles are of the conventional railway pattern, and the wheels are balanced. Tires of standard dimensions are fitted, thus facilitating replacements.

The water and coal bunkers are mounted on the engine truck. The car may thus be watered and coaled by the standard appliances. One of the objections which has been raised to the use of rail motor cars is that they occupy too much shop room when under repair. This objection has been overcome by making the engine truck readily removable. Where a number of these cars is operated, a spare engine truck may be kept to replace a truck in for repairs, and thus enable the car to be kept in service.

Controls and Equipment

The car is arranged with controls at each end so that it may be driven in either direction from either end without the necessity for reversal at terminals. A drifting valve is used to permit free coasting, and a system of electric bell signals is arranged so that the operator or engineer may communicate with the fireman when the car is running with the engine truck in the rear. The car is fitted with automatic vacuum brake and hand brake, and with Westinghouse steam-heating apparatus. Side buffers and draw-hooks are provided to enable the car to couple with the standard rolling-stock. The trailer truck is of light but robust construction and follows accepted practice in British car design. Standard wheels and axles with rolled steel disc centres are used. The axle-boxes are fitted with Hyatt flexible roller bearings. Stone's system of electric lighting is provided, with the dynamo driven from one of the axles of the trailer truck.

Body and Underframe Details

Referring more particularly to the type of car now being tried experimentally on the London & North Eastern Railway, the body frame and underframe are designed structurally as a unit and the body frame assists the underframe in withstanding stresses. The frames are constructed of rolled steel members, and the body sides and roof are sheeted with steel panels. Snap-headed rivets are used on the roof, and the riveting on the body sides is countersunk on the outside to preserve a flush finish. The modern tendency towards flush surfaces and the abolition of heavy mouldings in interior finish for railway carriages has been complied with. The interior of the passenger saloon is finished in polished teak. The ceiling finish is white. Parcel racks are fitted over the side lights and run the full length of the passenger compartment. The metallic fittings are of a polished brass. The floor is covered with linoleum, and the seats are upholstered in black and gold fabric. The car is well lighted, and well ventilated, and there are no lodgment places for dust.

The body is mounted at each end on a swinging bolster disposed midway between the axles. Double-coil helical bolster springs are used, having a deflection of ½-in. per ton. The laminated bearing springs through which the load is transmitted to the axles have a deflection of 1 in. per ton. The car runs smoothly and quietly at all speeds. The seat end frames are of cast metal. A noticeable feature is the light weight of the seat frames, the end frame for a double seat weighing only 4 lb. 9 oz.

There are four compartments—a driving compartment at the front, a passenger compartment to seat 60 passengers, a baggage compartment, and a driving compartment at the rear. Access is given to the passenger compartment and baggage compartment by sliding doors with an opening of 2 ft. 9 in. Hinged doors are provided to the driving compartments. Communicating doors are provided in all partitions. Four drop lights are fitted on each side of the passenger compartment, controlled by window regulators. The car is finished in the usual standard style of the London & North Eastern Railway for rolling stock, the exterior being in teak color, grained and varnished and lined primrose. The transfers are in gold leaf, shaded red, black and brown. The tank is painted locomotive green, and suitably lined. The underframes and trucks are painted black.

The principal dimensions of the car are as follows:

Gauge	4 ft. 8½ in.
Length	56 ft. 7¼ in.
Centres of trucks	42 ft.
Truck wheelbase	7 ft.
Overall height	12 ft. 10¼ in.
Height to top of roof	12 ft. 2¼ in.
Overall width	9 ft. 3 1/16 in.
Width over side mouldings	8 ft. 10 9/16 in.
Weight (complete with 3¼ tons of water and coal)	31 tons

Articulated Cars

When desired, and where conditions permit, the Clayton steam rail car is supplied as an articulated car with the power unit in the centre and a driving compartment at each end. A typical arrangement is shown on one of the accompanying drawings.

Egyptian State Railways Car

In this car the engine, boiler, transmission and other details are the same as in the vehicle already described, but there are certain differences in the body construction to which attention may be called, these being mainly effected to meet the climatic conditions obtaining in Egypt.

The body frame and underframe are designed structurally as a unit, and the body frame assists the underframe in withstanding stresses. The frames are constructed of British standard rolled-steel sections, and the body sides and roof are sheeted with steel panels. Snap-heated rivets are used on the roof, and the riveting in the body sides is countersunk on the outside to preserve a flush finish. The body is divided into four compartments, a driver's compartment at the front, a third class and a second class compartment for passengers, and a driving compartment at the rear. The third class compartment seats 49 passengers.

The second class passenger compartment seats 16 persons. The seats are upholstered in maroon buffalo hide. The floor is double, with packing between to act as a sound insulator. The floor is covered with dark green linoleum. Metallic fittings in this compartment are in statue bronze and the panelling is in polished mahogany. Falling lights and louvres are provided in each window opening in the passenger compartments. The windows are provided with brass frames. A sun vizor is fitted over each end window, and the top half of each end window is arranged to lower. The glazing in the doors and the bottom end lights is in neutral-tinted glass.

Ventilation

Torpedo ventilators are fitted in the roof, and are provided with permanently-open grids in the third class compartments and with regulators in the second class compartment. Ventilators are also fitted above the windows. The car is carefully insulated against heat. The inner surface of the roof sheets is lined with cellular asbestos sheets. A "dead" air-space of 2½ in. is maintained between the inner roof and is of asbestos millboard. Two large adjustable ventilators are provided in the roof of the boiler compartment.

The principal dimensions are as follows:

Gauge	4 ft. 8½ in.
Length overall	56 ft. 7¼ in.
Centres of trucks	42 ft.
Truck wheelbase	7 ft.
Overall height	13 ft. 0½ in.
Height to top of roof	12 ft. 4½ in.
Overall width	9 ft. 9¼ in.
Width over side mouldings	9 ft. 3¼ in.
Weight (complete with 3¼ tons of water and coal)	33 tons

The cars were tested with a passenger load on State Railways. The exterior is tippled brown with the Egyptian State Railways' standard transfers and garter. The roof is painted white. The underframe and bogies are black japanned. A cattle-guard is fitted at each end of the car.

Service Tests

The cars were tested with a passenger load on the London & North Eastern Railway, between Lincoln and Woodhall Junction. The purpose of the test was not primarily to obtain figures for performance, but to run the cars in. There are some severe curves on this section, and on the first run the restrictions governing speeds on curves were carefully observed. After the steadiness of the cars on curves had been suitably demonstrated, the curves were taken at speeds of cars at all speeds of from 30 to 40 m.p.h. The smoothness and quietness of the cars at all speeds was very noticeable.

Locomotive Tenders and Track Tanks

By Arthur Curran

The popularity of large tenders may well be made the occasion of a few remarks on the general subject of fuel and water, with special reference to certain factors governing the use of the latter.

Many railroad men have heard of track tanks—even though these are not used on their roads—and know, in a general way, what they are for and how they function. It can do no harm, however, to repeat that these track-tanks are intended to eliminate water stops, and enable long runs to be made without undue loss of time.

In England, where the idea originated, there was a further consideration, this being the limitation of the weight of tenders. Due to the extensive use of the track-tanks for "troughs," as they are called in that country—the typical English tender is still a six-wheeled affair, though its tank capacity has been creeping up steadily, especially during the past twenty years.

The idea of keeping down the weight of tenders was not confined to England, but had many supporters in America. Many of us doubtless recall the six-wheeled tenders at one time in use on the Pennsylvania and on the Burlington, just to mention a couple of roads.

Still later, a prominent trunk-line which, theretofore, had been using 8,000 gallon tenders on Pacific type locomotives, ordered 7,500 gallon tenders for the next group of engines of this type. This road, by the way, is now one of the leaders in the drift toward large tenders. The reversal of policy must be due to sound reasons, as the road is well known for shrewdness.

Various other roads, which also are equipped with track-tanks, are, nevertheless, "going in for" large tenders. When trains are running on short headway, and scooping water in rapid succession, the pans are quickly emptied. When, by reason of severe weather or other cause, the track-tanks cannot care for the traffic, engines are obliged to stop for water. The large tender is the answer to all of these conditions.

Obviously enough, the value of the large tender on roads not equipped with track-tanks need not be explained. The fuel question is somewhat different, though here again the large tender has its value. In some cases it is possible to "double a division" without replenishing to fuel supply. Clearly enough, this reduces the "turn around" time and the cost of labor. An engine that can be "put across the table" in a hurry is sometimes worth two others to the traffic department.

On certain English lines, where a very high grade of steam coal is used—mostly good "lump"—it is possible to "get over the road" on a tank of coal that would amaze some American engine crews. Of course, this encourages the use of comparatively small tenders. It is interesting simply as showing the difference of conditions in the two countries.

However, on the English railways which use a power grade of coal, the size of tenders is noticeably larger. From which it might be possible to draw a moral! Be that as it may, mere weight is not objectionable so long as it is useful weight. Certainly, the principles of the "flivver" cannot be applied to railway motive power.

Thirty or forty years ago a 3,500 gallon tender was considered ample, but it must be remembered that, in passenger service, a trainload of, say, 150 to 200 tons was considered large. Somewhat later, the 4,500 gallon tender was popular, at which time passenger trains were getting around 250 to 300 tons. The 5,000 and 6,000 gallon tenders appeared in due course. When steel cars put the weight of passenger trains up around 600 or 700 tons, the 7,000 and 8,000 gallon tenders came on the scene.

All this time, the American railways having track-tanks continued their use, with the exception of one road which evidently reached the conclusion that the trouble and expense of maintenance outweighed the advantages of the system. Of course, that is a question for individual determination.

It is in freight service, however, that the large tender—with a capacity of 10,000 gallons and upwards—has its most important field. Since the weight of freight trains is far in excess of anything in passenger service, and since, moreover, the possibilities of delay, en route, are greater; it is a matter of consequence to insure a good supply of water in case a heavy "drag" is "laid out" at a point not near a water station.

Old-time engine crews used to "cut and run" for water under such circumstances, but the conditions of modern railroad traffic do not encourage such a practice. Imagine a dispatcher with a lot of "light engine movements" on his hands, in addition to the regular rush of revenue trains! The methods of yesterday will not do for today.

4-4-0 Type Locomotive Scooping Water at Speed in England

So far as I know, the track-tank system is not being extended, though its value, under suitable conditions, is unquestionable. The cost of installing automatic stops is such as to discourage expenditures for other trackside devices or additions to permanent way.

However, the track-tank has played an important part, both at home and abroad, in the development of high-speed service. Having established that service, the railways may continue it, either with or without the device which fostered it. "Other times, other customs."

Curiously enough many people could not understand the very simple function of the water-scoop. They knew, of course, that "it worked," but how, was a mystery to them. A few even doubted the existence of such a device, as I once gathered from the sarcastic blather of an exceedingly ignorant man.

Scooping water at speed is illustrated by the accompanying photograph, which was taken on the Great Western Railway of England. The engine is a 4-4-0 type of the "County" Class, and the view presents a good idea of the fine and roomy arrangement of the four tracks.

The only puzzle in the picture is the small stock-car, which is the first vehicle in the train. What it was doing in the "consist" of a fast passenger train is not easy to explain. It loaded, the occupants were, doubtless, refreshed by the sight of so much water, even if they missed the "slushing" provided for in American law!

Fuel Oil Used by Railroads in 1926

Increased prices of fuel oil, especially in the South Central States, and increased efficiency in its utilization, especially in California, Texas, and Louisiana, caused a slight decrease in consumption by the railroads of the country in 1926, as compared with 1925, says the United States Bureau of Mines, Department of Commerce, in a recently issued report. Although the general consumption of fuel of all kinds by Class I railroads increased 0.53 per cent in 1926 over 1925, the quantity of fuel oil consumed by locomotives on Class I railroads decreased 0.33 per cent, and the fuel oil consumed by all railroads from which information is available decreased 0.9 per cent, from 69,461,119 barrels in 1925 to 68,836,850 barrels in 1926.

During 1926, a total of 71,446,956 barrels of fuel oil was purchased by the 152 Class I, II, and III railroads included in the Bureau of Mines compilation. Of the total amount purchased, 68,836,850 barrels was consumed, and 2,610,108 barrels added to the quantity in storage.

Of the total consumed, 59,329,690 barrels were burned as locomotive fuel; 9,507,160 barrels were consumed in shops, power plants and other uses than firing locomotives.

Although each of the 152 railroads used some fuel oil in its operations, comparatively few used it in large quantities. Only two railroad systems purchased more than 5,000,000 barrels each; and these two consumed jointly nearly half the fuel oil burned by railroads in the United States. Only six railroads purchased between 2,000,000 and 5,000,000 barrels, 19 railroads between 500,000 and 2,000,000 barrels, 19 railroads between 100,000 and 500,000 barrels, and eight railroads between 50,000 and 100,000 barrels, while 98 railroads purchased less than 50,000 barrels during the entire year.

As in 1925 more than four-fifths of the oil burned by railroads in the United States was consumed in the South Central States and in California.

From 15,577,670 barrels in 1906 the consumption of oil as a locomotive fuel has grown more than fourfold in 20 years.

No uniform national tendency either toward the conversion of the coal-burning locomotives to oil burning or the reverse, can be deduced. The quantity of fuel oil used each year varies in each region with the relative costs of oil and coal, the volume of traffic, the adoption of oil burning by railroads previously burning coal or the reverse, and the efficiency of burning.

During 1926, eleven oil-electric locomotives were placed in service and one in April, 1927. Twelve 60-ton, 300-horsepower, and three 100-ton, 600-horsepower locomotives of this type were in use on April 1, 1927. Thirteen of these were in switching service in New York, Philadelphia, Chicago, and St. Paul; one in Utah copper mining operations; and one employed by a California lumber company. Four more oil-electric locomotives were under construction at the end of April, 1927, one 145-ton, 750 horsepower; two 100-ton, 600 horsepower, and one 60-ton, 300 horsepower locomotive.

Manufacturers are experimenting with the construction of larger, more powerful oil-electric locomotives. One company was building in May, 1927, an experimental 1,000 horsepower oil-electric locomotive, using a six-cylinder, 4-cycle Diesel engine. A second manufacturer is working on a locomotive with a 12-cylinder, four-cycle engine rated at 960 horsepower at 325 revolutions per minute. Three other companies are working on locomotives with a six-cylinder, four-cycle engine rated at 750 horsepower at 500 revolutions per minute. One railroad company has designed a new type of Diesel locomotive and is building three of these locomotives in its own shops.

Performance of 120-Ton Storage Battery Locomotive[*]

Its Service in Chicago Terminal Freight Yards

By Edward Taylor, Ass't. Engineer, Railroad Electrification General Electric Co.

Railway yard switching in Metropolitan areas involves problems and limitations not met with in less densely settled districts and as these centers have grown and the volume of traffic has increased the law-enacting bodies in these congested areas have in many cases enacted regulations, laws and rules to insure that property and personal rights are not infringed by obsolete methods being extended when more desirable equipment is available.

The Chicago Chamber of Commerce, in 1915, arranged to have a report prepared by competent engineers who were to determine by tests and investigation the extent of the smoke nuisance and to explore the possibility of mitigating the smoke, and noxious gas situation as applied particularly to the downtown area. A report was prepared and certain ordinances were passed.

On casual inspection it appeared that a complete solution of the problem, as far as that part of the smoke and noxious gases emitted by the steam railroads, was possible by means of electrification, and it may be said that a complete electrification of all the terminals would eliminate all the smoke and offensive gases caused by these railroads. However, the question of the practicability of this change involved many factors, such as relative economies of the two motive powers, the relative advantage from an operation viewpoint, the reliability of the new method and the feasibility of installing either an overhead or third rail current distribution system.

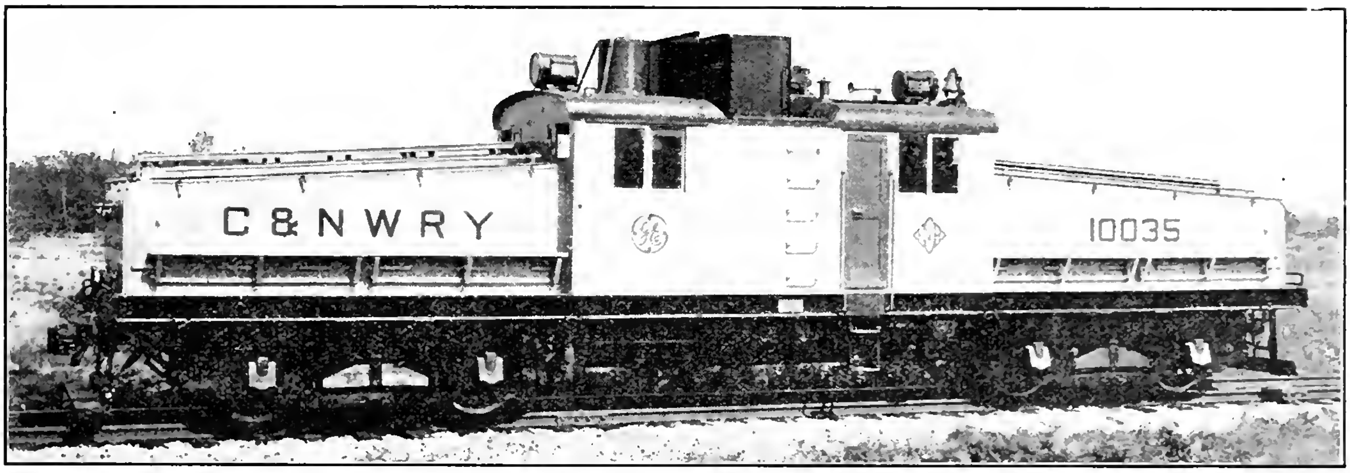
There are many kinds of track in Chicago presenting varied features such as main line, classification yard, coach yard, yard transfer track, team track, icing track storage and industrial track, etc. Some of these tracks are readily adaptable for electrification and present no particular difficulty. However, much of the track is so infrequently used as to make it uneconomic to equip it with a distribution system and bond the running rails. Other track, such as icing and team tracks provided no suitable place for the distribution contact system for the collection of energy for operation. It was observed that there were two distinct types of trackage to be considered, one that could with little physical difficulty be electrified, and second, tracks which could only be electrified with much difficulty.

The contact or distribution system offered the only physical problem and incidently the only economic difficulty.

It appeared from closer study that a combination system of straight electrification and Storage Battery on the motive power units would go far to solve the trouble, and further that the character of the load, and hauls were important as the storage battery has distinct limitations.

Yard switching data was somewhat meager and conflicting as would be the case where the operating conditions were so radically different. A testing equipment using the usual available dynamo-meter car and weighing coal, were not considered adequate for even a fair approximation of the quantitative values and it would be impractical to equip a sufficiently large quantity of track with contact system.

It was therefore decided to design and construct a suitable yard switching storage battery locomotive in order to explore its usefulness as an operating tool to do the work and further to determine its economic possibilities.



Electric Storage Battery Locomotive in Service on the Chicago & Northwestern Railway

A locomotive was built with the following specifications and characteristics.

General Description

Storage Battery Locomotive No. 10035

Dimensions:	
Total height	14ft. 6½in.
Width over rain guard	10ft. 3in.
Width over grab handles	10ft. 7⅜in.
Length over sill	49ft. 0½in.
Truck centers	31ft. 0in.
Length over face of couplers	52ft. 0in.
Rigid wheel base	8ft. 0in.
Weight:	
Locomotive complete	237,000 lbs.
Storage Battery	78,960 lbs.
Performance:	
Tractive effort 6 miles per hr.	39,200 lbs.
Tractive effort 12 miles per hr.	14,700 lbs.
Locomotive horsepower	800 H.P.
Maximum tractive effort at 30% coefficient of adhesion	71,000 lbs.
Maximum speed, light	30 m.p.h.

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[*] *A paper to be presented before the American Institute of Electrical Engineers of Chicago.*

EQUIPMENT:

4—GE-287 motors—200 HP at 300 volts each, with forced ventilation.
Gear reduction 66/16-39" wheels.

1—Winton gas engine—Model 106-A-220 HP—1000 RPH—6-cylinder—7¼ x 8" cylinders—direct connected to DT-509-A shunt wound—230-volt generator. Radiator for engine is blown. Capacity of gas tank 150 gal.

1—Storage battery "Exide Ironclad"—120 cells FL-31, 2,700 amp. hr. capacity at 230 volts, or 616 Kw. hours.

1—PCL control—20 points, including tap field.

1—CP-26, 100 cu.ft. compressor.
Straight and automatic air brakes.
ARA draft gear with 5 x 7 in. shank.

Storage batteries are the only devices in common use which function electro-chemically rather than electro-magnetically. They are the source of power for operating locomotive No. 10035. The type used was developed for submarine service where the highest quality is essential and was selected for use on this locomotive after an extended investigation into the merits of all types had proved that this type was best suited for the kind of operation for which this locomotive was designed.

Its equipment of batteries consists of 120 cells with a total weight of 40 tons. This weight is placed half on each of the two locomotive trucks, so that every locomotive wheel is a driver. The power is available to the traction motors instantly and in such quantities as is required by the work. The normal battery rating is 450 amperes for 6 hours. Due to the high discharge rate characteristics of this battery a current of 28 times this amount can be drawn from the battery for short periods. The weight of batteries on drivers, giving greater than normal track adhesion, can be utilized thus for occasionally doing work which would be beyond the normal rating of this locomotive.

A storage battery may be considered a potential source of power containing a very definite amount of energy, in this case 616 kilowatt-hours or 821 horsepower hours. As pointed out it is unique in that this power is available for use at any instant, at any rate desired, from 100 amperes which could be used continuously for 27 hours, to 6,000 amperes for short time operation. In order to get the best service from a battery locomotive its characteristics should be taken advantage of; that is, its assignments should be of such a nature that the average work to be done, including all heavy drags and all stops, allows the batteries to hold up for a reasonable length of time. For instance on a 16-hour job the average rate of work should not exceed 38 kilowatt hours per hour and on an 8-hour job, should not exceed 77 kilowatt hours per hour unless means are provided for recharging the batteries while working.

As between batteries of the same construction the life of each depends primarily upon time and temperature. That is, a battery which is used within its discharge rating and thereby is not allowed to attain too high a temperature, will have a much longer life than one which is habitually overloaded. The battery on this locomotive is large enough for the other equipment so that in the service for which the locomotive was designed it is operated well within its rating. Therefore, it is expected to give more than the four years service nominally considered its life.

Each of the 120 cells in this battery consists of a rubber jar containing the plates and electrolyte. Each jar rests in a wooden tray as high as the cell itself and provided with crane-eyes for hoisting the cell from its main compartment in the locomotive. Each jar is insulated from each adjacent one and from the compartment floor with porcelain insulators. To replace a cell it is necessary only to unbolt the copper connection straps and raise the cell.

About once a month replenishing water is needed to compensate for evaporation of water from the electrolyte through a vent hole provided in each cell. Ordinary water is used for this purpose, taken from any convenient hydrant and run into the cells through a hose after the combined filling and vent plugs have been removed from the top of each cell. This filling and an occasional overcharge to equalize the condition of each cell are all the attention which the battery requires. This is the extent of work done on the locomotive storage batteries during eight months of switching service on six Chicago railroads.

Different railroad terminals will have local limitations, restricting their choice of motive power over a wide range; for instance, the yards operated in these tests varied over 20 to 120 kw.-hours per hour and length of duty from one 8-hour shift to two 8-hour shifts as necessary, and it appeared desirable to have continuous 24 hours operation per day in service. This last is only possible where there is some overhead or third rail contact system to recharge the battery while engine is in switching duty. This attractive 24 hours service emphasizes the advisability of a combination electric and battery engine. A self-contained unit capable of operating long periods off the electrified track but self-recharging when running over convenient trackage to electrify, appears to meet many of the operating conditions of the average Metropolitan Railway yard.

The storage battery locomotive has demonstrated in actual switching service over sufficient length of time and over widely varied conditions that as a tool for the work it compares very favorably with the steam locomotive. Its advantages are as follows:

Within the capacity of the battery charge it performs the duty more promptly or "snappily" than its steam counterpart. It has a very high factor of availability and unusually low maintenance costs. Its necessary auxiliary appurtenances are low as compared to the steam locomotive. Its ease of manipulation and operation is in marked contrast to existing types and the lack of smoke, and steam in cold weather, improves the vision and consequently saves time and reduces casualties to personnel and material.

120-Ton Storage Battery No. 10035

This locomotive has 616 kw. hrs. capacity with one charge of the battery and on one charge will do the following:—

1.—It will make 340 runs of .119 miles, including acceleration, with a trailing load of 306 tons, (5 61-ton cars) at an average speed of 5.4 m.p.h. over a period of 12.5 hours, which allows 60% for actual running time.

2.—It will haul a 306-ton trailing train (5 61-ton cars) one half mile, including acceleration, and make 101 such moves at a balanced speed of 17 miles per hour on one charge of the battery.

3.—It will haul a 500-ton train (8 62½-ton cars) at 16 m.p.h., taking 6 pounds per ton for traction, at an hourly output from battery of 147 kw.-h. and will continue to haul it for 4.2 hours, or it will haul the 500-ton trailing train for 67 miles, or 33,500 trailing ton miles on one battery charge.

4.—It can exert a tractive effort of 60,000 pounds at 3 m.p.h. It is controlled handily and smoothly, has a high factor of availability, requiring a minimum of time for getting ready, and a minimum of attention when not operating.

5.—It can do twelve hours of the average yard switching service of all the railroads in Chicago on one charge and can be recharged in six hours. This locomotive is equipped with a socket for charging from central station off-peak power at relatively cheap rates.

6.—It can readily be equipped with a 25 or 60 cycle motor coupled to the present generator, and in connection with a pantograph, collect its replacing charge if desired from a simple trolley carried over a convenient track and thereby be available for service twenty-four hours a day.

7.—This engine operates quietly, without smoke, noxious gases or steam and is a handy tool for the work of terminal switching and sounds a new note in motive power for congested terminals.

8.—Its operation is more economical than steam and it may be a preliminary step to a progressive electrification if desired.

This storage battery locomotive, fully equipped with instruments, was completed in October 1926 and run to Chicago on its own power hauling a 60-ton coach, a mean speed of 32 miles per hour while running was recorded. On arriving in Chicago it was turned over in turn to each of six of the class "I" roads for service tests and trials, displacing in each case the usual steam locomotive. No restrictions were placed on its service except to point out that it was a switcher rather than a road locomotive.

The following represented typical switching service in the Chicago Yards:—

Average weight train incl. locomotive....	425 tons
Average length all switching moves.....	628 feet
Average distance traveled by locomotive in one 8-hour shift................	26 miles
Average speed while in motion.........	5.4 m.p.h.
Average ton-miles for steam locomotive on usual two 8-hour shifts per day..	22,000 ton-miles
Proportion of time in motion while assigned	60%
Coal consumed per hour...............	.37 tons

On account of the various types of locomotives used and the methods of operating the locomotives, it seemed advisable to investigate several systems so that a fair mean duty could be arrived at, and the following tabulations are the results of service operation.

Summary of Operation in Wood Street Yards

Kind of Work	No. of days TOTAL	Kw-hrs. used by loco. TOTAL	Assigned wkg. hours TOTAL	Miles of Oper. TOTAL	Av. kw. used by loco. during wkg. hrs. incl. all stops		Av. miles per hr. during wkg. hrs. incl. all stops	
					Av. per day	Av. for hardest day	Av. per day	Av. for hardest day
Heavy switching	3	1660	20	62	119	151	3.1	3.7
Pulling freight	4	2080	24.5	115	122	181	4.7	5.8
Roustabout	7	3280	56.5	207	81	104	3.5	3.3
Booster	1	450	7	26	92	92	3.7	3.7
Break up	4	2460	34.5	127	102	125	3.7	4.2
Pass. terminal (days)	4	1775	34	188	75	91	5.5	7.4
Pass. terminal (nights)	3	728	24	78	43	49	3.2	2.5

During the four days of passenger terminal work the records showed a power consumption averaging 70.6 watt-hours per gross ton-mile.

Summary of Operation in Wood Street Yards

While this locomotive was in service in October and November, 1926, in the Wood Street yards, it was assigned to the various jobs ordinarily performed by 90 and 120 ton (weight on drivers) steam locomotives.

The following tabulation is a summary which is of interest in showing the actual power required for these jobs:

The movements of the locomotive from the battery charging station and return are included in the above tabulation. The total trailing ton-miles handled during the four days was 16,863 ton-miles.

Summary of Operation in Jackson Street Yard

During December, 1926, this locomotive was in service principally in the yards north of Congress Street. The kind of work may be classified under two headings as shown with the length of time in each service.

Freight switching (8 days of 16 hours each).

Baggage switching in the passenger terminal yards (2 days of 16 hours each).

Operating data is as follows:

	Freight Switching	Baggage Switching
Locomotive miles per 16-hr. day	36.2	33.0
Trailing ton miles per 16-hr. day	13,960	5,000
Average trailing load	360	151
Average gross load	480	271
Average length of movement (feet)	517	356
Average speed while in motion (MPH)	6.7	4.7
Average speed including all stops (MPH)..	2.4	2.1
Average speed including all stops on hardest day (MPH)	2.9	2.0
Per cent standing time	64.5	56.5
Kilowatt-hrs. used by locomotive per 16-hr. day	1,140	783
Average kilowatt	71.5	49.0
Average kilowatt on hardest day	85.6	49.8
Watt hours per gross ton-mile	61.5	86.5

During this period the electric locomotive operated in regular yard service and performed successfully in comparison with the regular 70-ton six-wheel steam switching locomotives. In fact, on some unusually cold days it was one of the few locomotives in the yards doing its full quota of work.

Description of Type of Service

Classification Yard No. 1—The storage battery locomotive was used in heavy classification switching and did the work which is ordinarily done by a 95-ton (on drivers) steam locomotive.

Coach Yard—The work consisted of hauling main line passenger trains to and from a "Y" point for turning, and miscellaneous switching in a passenger coach yard. The steam locomotive ordinarily used in this work weighs 64 tons on drivers.

Union Depot—This work consisted of switching express and mail cars in and about the main passenger terminal. The battery locomotive in this service replaced a 64-ton (on drivers) steam locomotive.

Summary of Test Results Jan. 19, 1927, to Feb. 2, 1927

		Classification Yard No. 1	Coach Yard	Union Depot	Kinzie Street Yard
(a)	No. of days under test	3	1	4	3
(b)	Total hrs.-minutes in service	23–25	7–38	28–26	22–11
(c)	Total miles light	17.3	16.1	33.1	20.1
(d)	Total miles loaded	55.7	22.3	70.4	31.2
(e)	Total mileage (c+d)	73.0	38.4	103.5	51.3
(f)	Miles per day (e÷a)	24.3	38.4	25.9	17.1
(g)	Ave. HPH in service	3.11	5.03	3.64	2.32
(h)	Ave. HPH while in motion	4.70	8.53	7.56	4.10
(i)	Per cent time in motion (100 g/h)	66.4	59.2	48.4	56.6
(j)	Total No. of cars handled	966	56	427	507
(k)	Total gross ton-miles	33,413	20,351	28,518	13,004
(l)	Ton-mile per day (k/a)	11,138	20,351	7,129	4,335
(m)	Total Kw-hrs. used	2,640	692	1,484	1,230
(n)	Watt hrs. per gross ton-mile (1000 m/k)	79.2	34	52.1	94.7
(o)	Ave. Kw. in service (m/b)	104	91	52	55
(p)	Hrs. on one battery charge (616/o)	5.9	6.8	11.0	11.2

Kinzie Street Yard—Industrial switching. The 64-ton on drivers steam locomotive is ordinarily used in this work.

Summary of Operation in LaSalle Street Terminal

On March 26, 1927, storage battery locomotive No. 10,035 took over for three weeks the assignment of one of the six-wheel steam switching locomotives in the LaSalle Street passenger station.

The work of the switching locomotives in this terminal consists of running in after incoming trains, pulling the cars out to relieve the inbound locomotives and placing the cars on other tracks ready for outbound service or spotting them on express or mail tracks. Trains are also split up and rearranged, and cars put on storage tracks. This switching occupies main line track and must be done without interfering with the 150 scheduled train movements daily.

The storage battery locomotive handled this work from March 29th to April 1st very satisfactorily. A summary of the averages obtained from a three-day test in this service is as follows:

	Average per Day
Number of moves	82
Hours on duty	7.8
Mileage while working	25.9
Mileage of locomotive light	9.1
Number of cars moved	177
Kilowatt hours of energy used	461
Per cent time standing	40
Miles per hour including all stops	3.3
Length of average movement in feet	1,670
Total trailing ton-miles	3,014
Average trailing tons	116
Gross ton-miles per hour	785
Average kilowatts	59
Kilowatts-hours per locomotive-mile	17.8
Watthours per gross ton-mile	75.3
Hours for complete discharge of battery	10.4

Data from 22 Days of Operation

	Average Day	Hardest Day
Hours on duty	8.6	8.7
Mileage while working	28	31
Kilowatt-hours of energy used	490	600
Miles per hour including all stops	3.3	3.6
Kilowatt-hours per hour	57	69
Hours for complete discharge of battery	10.8	8.9
Number of loaded cars moved	1045	

Operation of Storage Battery Locomotive in Kinzie Street Yard

On February 15, 1927 a complete record was made of a typical day's work of freight terminal yard switching in the Kinzie Street Yard. The following is a summary of this day's work:

Locomotive-miles from roundhouse to Kinzie St. Yard and return	6.67
Light locomotive-miles in Kinzie St. Yard	6.50
Loaded locomotive-miles in Kinzie St. Yard	12.73
Total locomotive-miles	25.90
Total time in Kinzie St. Yard	9 hrs. 57 min.
Percentage of this time standing	54 %
Percentage of this time in motion	46 %
Locomotive ton-miles while in Kinzie St. Yard	2327
Trailing ton-miles	2893
Total ton-miles in yard	5220
Battery discharge while in yard	428 kw.-hrs.
Average kw. in yard	42.9
Average kw.-hrs. per locomotive-mile in yard	22.2
Average watt-hours per total ton-mile in yard	82.1
Average miles per hour	1.94
Average miles per hour while in motion	4.22

Summary of Storage Battery and Steam Locomotive Tests for 6 Days in Corwith Yard, May, 1927

Storage Battery Locomotive No. 10035

Total weight .... 120 tons
Weight on drivers .... 120 tons

	Average per Day
Hours on duty	7.4
Number of moves	278
Total mileage on duty	26.4
Light locomotive mileage	7.7
Number of loaded cars moved	897
Number of empty cars moved	552
Length of average movement in feet	512
Miles per hour including all stops	3.5
Total trailing ton-miles	6027
Average trailing load in tons	224
Gross ton-miles per hour	1241
Kilowatt hours used	584
Average kilowatts	79
Kilowatt-hours per locomotive-mile	22.0
Watthours per gross ton-mile	64.3
Hours for complete discharge of battery	7.9

Steam Locomotive No. 2084 *(3-day test)*

Total weight .... 126 tons
Total weight on drivers 77 tons

	Average per Day
Hours on duty	7.4
Number of moves	295

Total mileage on duty	27.2
Light locomotive mileage	5.8
Number of empty cars moved	593
Length of average movement in feet	485
Miles per hour including all stops	3.6
Total trailing ton-miles	5190
Average trailing load in tons	191
Gross ton-miles per hour	1160
Pounds of Coal used (incl. firing up)	8300
Gallons of water used	3730
Pounds of coal per hour	970
Pounds of coal per locomotive-mile	268
Pounds of coal per gross ton-mile	.85

Summary of Test Results May 25 to June 1, 1927

	Bellewood Yards (Ave. per day)	49th Ave. Yards (Ave. per day)	Lincoln St. Yards (Ave. per day)
Number of movements	114	139	84
Hours in motion	5.5	5.2	3.84
Hours standing	2.9	2.3	4.18
Hours on duty	8.4	7.5	8.02
Total locomotive-miles	37.9	32.2	24.2
Light locomotive-miles	4.8	9.0	9.6
Total number of cars moved	745	979	153
Kilowatt hours of energy used	772	681	338.8
Per cent time standing	34.5	30.7	52.1
Miles per hour while in motion	6.9	6.2	6.3
Miles per hour including all stops	4.5	4.3	3.0
Total distance traveled in feet	200,112	170,016	127,776
Length of average movement in feet	1,755	1,223	1,521
Total trailing ton-miles	11,519	7,906	2,154
Average trailing tons	304	245	89
Locomotive ton miles	4,548	3,864	2,904
Gross ton-miles	16,067	11,770	5,058
Gross ton-miles per hour	1,924	1,570	631
Average kilowatts	91.8	90.8	42.3
Kilowatt hours per locomotive mile	20.4	21.2	14.0
Watthours per gross ton mile	49.0	57.9	67
Hours for complete discharge of battery	6.7	6.8	14.5

From the foregoing data it will be observed that a wide variety of service operation was included in these test periods, and it may be stated from observation and discussion with the operators that the battery locomotives, considered as a tool to do the work was superior to the steam locomotive when the battery locomotive was operated within its designed range of battery capacity.

The tests and service trials made indicate that for metropolitan yard switching a combination trolley, or third rail and storage battery locomotive using the electric distribution system on those frequently used tracks, where train movements were infrequent, may find a useful field of application. In many cases the storage battery could probably be recharged while operating under the trolley in an off-peak period.

Operating costs would vary according to actual costs of coal as compared to power costs and in order to make possible a preferred rate embodying off peak advantages it is assumed that central station battery charging current be used. Perhaps a power contract could be drawn embodying straight rate for operating on the trolley and a separate rate for off-peak metered separately to the battery.

The number of men in a yard switching crew is fixed so there only remains in a survey of the economics, the relative maintenance of the apparatus and the interest on the investment to be taken into consideration.

From published records of the Interstate Commerce Commission it is obvious that the maintenance costs of an electric locomotive as contrasted with equivalent steam locomotive is one-third to one-quarter that of the latter and this reduced maintenance of the electric machine implies a relatively high factor of availability for service.

Any analysis of the economies of the battery locomotive should have an item per year added to its operation cost to cover the entire replacement of the storage battery at the end of the operating life of the cells. A battery with low internal resistance is desirable permitting high discharge rates with low drop in voltage as inherently a locomotive of this type is a heavy duty low load factor machine.

As a metropolitan area becomes more intensively developed and the population per unit area becomes sufficiently high, there comes a time when the demands of the community for less smoke and noise from railway yards bear such weight that they point to the advisability of modifying the existing methods of operation. Fortunately enough, a change from steam motive power to a type which gives a minimum of noise and is free from smoke and dangerous or offensive gases, is not entirely without benefit to the railroad.

Several types of motive power have been developed for replacing the steam locomotive in switching service, each having characteristics which fit it for certain types of work. There are, in brief, the internal combustion type, such as the Diesel or the gasoline engine which drive the locomotive through the medium of an electric generator and railway type of geared motors mounted on the driving axles, and the straight electric type, which obtain power more or less directly from a central station generating plant. The latter may be further divided into the trolley type, the storage battery type or a combination of the two.

The straight electric locomotive using a trolley possesses all the requirements needed to meet smoke abatement measures as it is entirely free from smoke, cinders and gases, and produces a minimum of noise. Absence of smoke permits of speedier and less hazardous operation in yards. The electric locomotive is a rugged device which has a very low cost of maintenance as can be testified to by many years of operating records. Very few facilities are required as coal and water is not needed nor are turntables required since the construction of the locomotive is symmetrical with the control arranged for double end operation. Roundhouse space is not so necessary since the electric can be kept out of doors summer and winter; nor does the electric have to be taken into the roundhouse or shops for repairs as frequently as the steam. It can be kept continually working at the yards or terminal, thus saving crew time in going to and from the roundhouse and relieving the main line track of some non-revenue traffic. For the same weight on drivers, the electric locomotive can accelerate a given trailing load more rapidly than the steam by virtue of its more continuous torque, which permits of working on the average, nearer the slipping point of the wheels, and in addition the absence of the tender weight permits either the handling of additional useful load or more rapid acceleration with the given load. The time considerations mentioned above indicate that a given number of electric locomotives can do more work than the same number of steam locomotives, or that fewer electrics are required to do a given job of yard switching.

The trolley type of locomotive requires a distribution system which many roads hesitate to put in switching yards on account of the more or less complicated construction required and because certain considerations, such as icing of cars, or the limitations of industrial sidings do not permit of overhead trolley, nor is third rail generally considered to be a solution of these difficulties as the same limitations may exist with regard to industrial track and there is the additional hazard to switch and yard men.

The battery locomotive possesses most of the advantages of the trolley type with the addition of being more mobile; i.e., in emergency it can be used at considerable distances from its regular yard, whereas the trolley type is limited to electrified track. The weight of the battery is readily used to advantage by increasing the driver weight leaving the motors approximately the same size as before, the short time overload rating of the latter allowing development of tractive effort well up toward full adhesive weight. The battery is charged from central station power at a station installed adjacent to some convenient siding or spur in the yard, in which the locomotive ordinarily works, and in this lies one of the great advantages of the storage battery electric locomotive. Power for charging during off-peak periods, which usually aggregate 12 to 16 hours out of the day, may be obtained for as low as $.01 per kilowatt-hour, whereas direct-current power for the trolley type would be 50 per cent or more higher. This difference would be partially offset by the difference in efficiency of the storage battery and the distribution system so that the actual power cost at the locomotive drivers would be approximately $.0109 per horsepower-hour for the storage battery locomotive as compared with $.0146 or more, for the straight electric.

The necessity for charging the battery limits the number of hours per day during which the locomotive can be used. If advantage is taken of idle time, such as lunch hours or periods when there is no work, for charging, then the locomotive can be in hands of crew for about 20 hours per day as compared with the 16 hours maximum of the steam switcher. Maintenance of the battery increases the upkeep cost of the locomotive as compared with the straight electric, but this cost is partially offset by reduced cost of power and by absence of overhead trolley maintenance.

It not only meets smoke abatement measures and provides a simple effective tool for yard switching which can be installed quickly without extensive preparations, but it lends itself readily to existing electrifications and fills in excellently with future electrifications. If main line tracks are already electrified, the battery type locomotive can be equipped with a trolley or pantograph and be charged directly from the existing distribution system while working, and can work 24 hours per day with few, if any, additions to the distribution system. On non-electrified systems, when it becomes advisable to put in a straight electric type where the battery locomotive has been working, the latter is relieved for duty in other yards and thus a complete electrification can be built up with the development of the community without the necessity of great expenditure at any one time.

The electric industry can with profit to itself, fully explore the possibilities of a self-contained combination electric locomotive unit for metropolitan yard switching as the problems presented are not those usually met within the electrification of industries in general. The possible yearly kilowatt-hours are very high, however, the instantaneous and 15-minute peaks are out of the usual proportion, making it undesirable for individual power stations, as each one would have to install the full standby or reserve capacity. The large central station with its overload or peak facilities could with advantage all around arrange to take up these new loads and, it is possible in the future that we may see greater advances made when the railroad officials fully realize that a progressive scheme of terminal electrification is available by means of this self-contained combination locomotive.

An Incident in Train Operation Forty Years Ago

By Snomysew

When we read of bad railway wrecks, particularly collisions involving loss of life, our first thoughts run to the probable cause and how such accidents can be prevented.

We are sometimes advised that one train crew ran by their orders, or the flagman did not get out and warn a following train, or that the train dispatcher gave what is known as, "a lap order," etc., but, in all cases we are told that the collision should not and would not have occurred had those charged with responsibility have properly discharged their duties.

We then hear much of automatic train control, more rigid rules, etc., following which ordinary quietude prevails until the next bad wreck, when we go through the same process again.

In addition to the accidents and bad wrecks that have resulted from human fallibility, there are, of course, thousands of errors of judgment or slips of memory that might result in as bad or possibly worse wrecks than those that actually occur, but through good luck or providential causes are averted. Many of the wrecks of which we have knowledge would form the basis of a most fascinating story, if it were not for the fact that much suffering and misery are involved.

Among the mistakes made in connection with train movement that did not result in collision or wreck, lies the background of equally as interesting or exciting stories, if the parties thereto would relate them, but these are generally among the incidents in railway men's lives that are only recorded in the tablets of their memory, and so far as the rest of the world is concerned, they hold these secrets sacred, in a closed book.

There are, of course, some exceptions to the foregoing, and in order that those who do not realize just how close they may have come to injury or death in railway travel, and what peculiarly strange accidents do occur, an incident that actually occurred and might have, but did not result in loss of life, is related.

It must be borne in mind however, that this incident occurred about 40 years ago, when the physical property on the particular line was in bad shape, the volume of business light, and the morale of the men not up to the high standard of today. In fact, such an accident could not happen on that line today.

In 1887 the writer was in the employ of the Atlantic & Pacific Railway as a locomotive engineer between Williams, Arizona, and Mojave, California.

The track was in poor condition, the equipment worse, and owing to the difficulty in securing or retaining good men, particularly on the Mojave Desert division, the company's officers were rather lenient in matters of discipline. Consequently, there were some things that were "winked at" that would not be tolerated now, and were as a matter of fact, even at that time forbidden by the rules.

Among the conductors employed on the line was one whom we will call "Mr. Burnside," owing to the fact that he wore a rather heavy beard of a style known as "Burnsides." We all called him "Popp Whiskers" for short. Socially, he was a fine gentleman. This gentleman had for many years been a Pullman conductor on a short run in New England, and when well past 60 years of age, on finding himself in a tubercular condition, arranged through some influential friends who owned stock in the road to get him a temporary position as conductor, out on the desert, hoping that he might recover his health. So we have here to start with an inexperienced, sick old man, as conductor, on a job that was at times too hard for a husky, healthy young athlete.

On arriving at Mojave one evening after a hard trip through from Williams, Arizona, 438 miles, I was ordered to turn the engine, run light to Barstow 71 miles, and take a special, conductor Burnside, east to Needles. On arrival at Barstow about 9:30 p. m. I found the special train consisted of 4 or 5 empty or dead head Pullmans, that were badly needed to balance equipment at Kansas City, and 8 or 9 special freight cars. Three of the latter mentioned cars had neither air brakes or air pipes. These freight cars were on the head of the train, thus providing 6 air brake cars and engine tender to hold the train on grades, plus such help as the train crew might give with hand brakes in cases of emergency.

I protested against such makeup of the train, but was told that the Pullmans must be on the rear, and to whistle for help if I needed it.

On comparing watches, reading orders, etc., preparatory to leaving Barstow, "Popp Whiskers" confided to me that he was not feeling a bit well, and feared he might feel worse before we got to the Needles, and would I not "kinder look out for things, etc." I replied, "You have 4 or 5 empty Pullmans back there with some 60 or 70 beds and if you can't find a place to take a little rest, then you deserve to be sick."

I suspect Popp Whiskers took the hint, for when we got over to Bagdad, some 76 miles from Barstow at about 1 a. m., I had to send the head brakeman back to get him out to sign orders, etc., and he then again reminded me that he felt a "little grunty," and hoped I would land the train in the Needles all right. He said, "You won't need me, will you?" to which I said, "Lord no, you've got about 60 beds back there, crawl in and rest."

As we proceeded, I not only kept a close watch on the rear lights, but charged the fireman and head brakeman to do the same for fear that the rear end might become detached passing over rough track.

There was an ascending grade of more than 40 miles eastbound from near Cadiz to Goffs, and after we were well up this grade approaching Danby, the rear lights were checked from both sides of the engine. At Danby there was a water tank where we stopped for water, and on alighting to look over my engine, oil around, etc., I looked back and could not see any tail lights on either side, so I called to the head brakeman to run back and see what was the matter with the rear end, and "if they were all asleep, to wake them up!"

Pretty soon he returned gasping for breath and exclaimed, "there ain't no rear end, what in the devil will we do."

I said, "it can't be far away, as we both checked the tail lights 3 or 4 miles back near that double S trestle over the dry wash, so you get up on the rear car with your lantern, and as it is now breaking daylight we will go back slowly and pick them up."

I moved slowly down the grade and as daylight came we could not see the lost rear end. It seemed as though those 5 Pullmans had just dropped out of sight. I had no fear of meeting an opposing train, but was frightened to think of the result of those five Pullmans running into an opposing train, that might be following us. As daylight came and I could see miles away, I dropped down the grade faster and soon came in sight of the five Pullmans standing almost between the switches at Cadiz. They had run back some 8 or 10 miles, and I backed up 13 miles to get them.

An eastbound train was approaching, but as it was now almost sunrise, the engineer observed them and came to a stop without the benefit of rear flagging, which at the time was not possible as the occupants of the Pullmans were in the "sweet arms of Morpheus," and knew nothing of the break into and run away, until after the recapture.

We were hours late on arriving at the terminal of course and gave as the reason: "Delayed, account break in two on rough track, and hot boxes." Both statements were true, but the whoppers we concealed were enough to hang a man.

The rear brakeman quit on arrival at terminal and a short time thereafter "Popp Whiskers" took his hirsute adornments to other climes, and no formal inquiry, or disciplinary action was taken, although the real facts gradually leaked out.

The three freight cars without air brakes or pipe line, should not have been put into the train, thus leaving the five Pullmans and three freight cars without emergency air in case of break in two, back of the air braked cars.

The engineer should not have intimated to the venerable conductor, that a man with 60 or 70 empty beds and nothing to do all night long should have no trouble in getting a little rest, as the suggestion was evidently too tempting for him to resist.

A similar accident would be almost, if not altogether impossible now on that or most any other railway, although there are many narrow escapes for the same reasons as in this case, where either human agency or a divine providence intervenes to prevent actual loss of life and destruction of property.

When we recall that there are about 15,000,000 trains per year, or about 41,000 per day moved on our railways and that, aside from the train crews and day passengers, that about 75,000 passengers sleep in Pullman cars every night, it is surprising that accidents similar to above do not oftener result in loss of both life and property.

Strathcona Memorial Fellowships in Transportation

Five Stratcona Memorial Fellowships in Transportation, of one thousand dollars each, are offered annually for advanced work in transportation, with special reference to the construction, equipment, and operation of railroads, and other engineering problems connected with the efficient transportation of passengers and freight, as well as the financial and legislative questions involved. Transportation by water, highways, or airways, and the appropriate apparatus involved, and also other general aspects of the broad field of transportation, embracing its legal and economic phases, will be included in the lists of subjects which the Fellows may select for investigation and study. The holder of a fellowship must be a man who has obtained his first degree from an institution of high standing. In making the award, preference is given, in accordance with the will of Lord Strathcona, to such persons or to the sons of such persons as have been, for at least two years, connected in some manner with the railways of the Northwest.

Applications for these fellowships should be addressed to the Dean of the Graduate School of Yale University, New Haven, Connecticut, before March 1, on blanks which may be obtained from him. Applicants must submit with their application a brief biography, and a certified record of their previous courses of study in college or technical school, and their standing therein. They should also submit testimonials bearing upon their qualifications.

Various courses of study relating to transportation along engineering, economic, and legal lines are now offered by Yale University. For greater particularity the applicant is referred to the catalogue of the Yale University Graduate School, and especially to details found under the following groups and courses of study, viz: Social and Political Science; Government and Public Law; Civil Engineering; Electrical Engineering; Mechanical Engineering; Engineering Mechanics. Strathcona Memorial Fellows will be entitled to pursue investigation in those aspects of transportation in which the University now offers competent guidance and supervision.

Railway and Locomotive Engineering

A Practical Journal of Motive Power,
Rolling Stock and Appliances

Published Monthly by
ANGUS SINCLAIR COMPANY
136 Liberty Street, New York
Chicago Office: 168 North Michigan Avenue
Telephone Rector 0746. Cable Address "Locong." N. Y.

Harry A. Kenney, Prest. and Man. Ed.
W. E. Symons, Associate Editor
J. Snowden Bell, Associate Editor
Thomas P. Kenney, Secretary

LONDON REPRESENTATIVE
The Locomotive Publishing Company, Ltd., 3 Amen Corner, Paternoster Row, London, E. C., England.

SUBSCRIPTION PRICE

$2.00 *per year,* $1.00 *for six months, postage paid in the United States, Canada and Mexico. For other parts of the world,* $2.50. *Single copies,* 20 *cents. Remit by Express Money Order, Draft, Post Office Order or Registered Letter.*

Mailing address can be changed as often as necessary—always give old and new address, and if you subscribe in a club, state the name of the agent.

Please give prompt notice when your paper fails to reach you regularly.

Entered as second-class matter January 15, 1902, at the post office at New York, New York, under the Act of March 3, 1879.

Increased Tractive Power of Locomotives Have Reduced Operating Costs

Among the important factors in achieving dependable and economical transportation are locomotives of increased tractive power. This is part of the general effort of railroad management to get more tons into each car, more cars into each train, and more transportation out of each ton of coal, all for the purpose of distributing the expense of operating a train over a greater number of tons, thereby decreasing the cost of producing each ton-mile of transportation.

New locomotive construction is now marked by an aggressive effort on the part of designers and builders to produce a high capacity, efficient motive-power unit.

It is significant that with an increase of only 8 per cent —from 1911 to 1926—in the number of locomotives in service on the Class 1 lines, the railroads handled an increase of 10 per cent in revenue passenger traffic and an increase of 78 per cent in revenue freight traffic.

The remarkable progress made during this period in increasing the tractive power of the average locomotive was, of course, largely responsible for this accomplishment. In the 15-year period since 1911, the average tractive power per steam locomotive has been raised from 28,305 pounds to 41,873 pounds, an increase of 48 per cent. The 1926 figure represents the highest point yet achieved.

This increase in sustained capacity of locomotives has been accomplished principally by providing greater boiler capacity through the use of larger fire-boxes; more grate area; higher super-heat; higher pressure; and by the use of the limited cut-off or the three-cylinder arrangement.

These new locomotives are regularly hauling longer trains than their predecessors. The ratio of freight cars per train was 45.2 in 1926, according to the Interstate Commerce Commission, as compared with 43.8 in 1925 and 36.6 in 1920. For the first nine months this year, freight cars per train averaged 46.5, the best record for any comparative period during the past eight years. During the month of September alone the average was 48 cars.

The effect of increased tractive power of locomotives has naturally been reflected in the improvement which the railroads have made in the trainload carried. For the month of September, 1927, this amounted to 1,860 gross tons (excluding the weight of the locomotive), while the net trainload was 819 tons, both of which represent the best record of any corresponding month since 1920. For the first nine months this year, the gross trainload was 1,782 tons (excluding the weight of locomotive), while the net trainload was 783 tons. These figures also represent new records since 1920.

The Oil Factor in German Locomotive Experiments

The German State Railways have been experimenting with a turbine-driven express locomotive built by Maffei of Munich for some time, but as yet no engineering data are available to show how this machine compares in efficiency with the ordinary steam locomotive. However, the results indicated thus far seems to have justified the plan and design of another new engine along similar lines. It will be turbine driven and equipped with a Benson boiler in the tubes of which the water will be heated to over 700 degrees Fahrenheit, and the pressure will be nearly 3,400 pounds. Such a boiler is in successful operation in a Berlin power plant.

In the remarkable boiler referred to the water passes into a new physical state and the pressure is reduced to 2,700 pounds before utilization. This reduction results in a condensation of 30 per cent of the steam, which is superheated for further use.

The designers anticipate no difficulty in obtaining tubing able to withstand the enormous pressure required. The boiler is not of the flash type in which the water is converted into steam as it flows over highly heated tubes. The Benson principle is entirely different as it deals with a new physical state.

The designers of the new locomotive expect a reduction of 50 per cent in fuel consumption alone. The new engine will be lighter than the standard reciprocating engine of equivalent horsepower.

The Germans have been experimenting with Diesel locomotives, and successfully but their best engineers still feel that great obstacles must still be overcome and that the day is still far distant when any great number of German trains will be hauled by Diesel engines. The experiments in the use of such engines for hauling railway trains will be continued because of the Government's interest in processes devised for the production of oil, motor fuel and lubricants synthetically from coal.

To overcome the oil monopolies of other countries, designers are encouraged in the building of Diesel engines.

A Product of Combustion

The dusky diamond of the late song and the brilliant diamond of the African fields are known to be of kin, and while one is weighed by the carat and the other by the ton there is little doubt in the minds of anyone as to which the world could best do without. The one is carbon in its purity and perfection and glistens as a jewel rarity, while the real gem of utility is in the impure carbon of our everyday needs that we find in our coal, wood, coke and charcoal, in our peat, lignite, tar, oil and befouling smoke. "These are our real jewels," our fuel and their value increases in almost a direct ratio to the carbon that they contain.

But whether the carbon be pure or not, if it burns in oxygen or the air it produces carbon dioxide or carbonic acid gas, and the combustion is nothing but a chemical combination of the carbon with the oxygen and their resulting transformation into this gas. We know that if the two are formed in a firebox in the proper proportions, the whole will be transformed, the combustion will be perfect and the greatest possible amount of heat will be developed. But if the carbon is in excess relatively to the air, then we have, as a resultant of the incomplete combustion, carbonic oxide and smoke, which may even have their uses as an actual economizer despite the fact that they are both actual wasters.

Of the three forms smoke alone manifests itself to the senses and hence the abolition of smoke is usually regarded as the mark of perfect combustion though its absence does not necessarily indicate that the actual combustion is all that could be desired. Carbonic acid gas, or scientifically carbon dioxide, as it exists in fireboxes is a colorless gas, almost odorless, of a slightly acid taste, asphyxiating, partially soluble in water, capable of being liquefied by pressure and solidified with cold, with high expansive properties and about two and a half times as heavy as air. "There, that's its photograph done with care." It may be mentioned, in passing, that its capability of expansion from the liquid form has led a number of experimenters to attempt to utilize it as a motive power; attempts that have not yet reached the threshold of success. Its three chief characteristics are, that being itself a product of combustion it will not burn, but makes a most effective fire extinguisher even putting out the fire that generated it when no outlet is afforded. Its presence in a badly ventilated apartment causes great discomfort, a heaviness in the head and sleepiness, and apropos of this subject of ventilation and the need of it on railway cars, it will be noted that in the winter, when the doors are closed and sufficient ventilation is not provided for the passengers within, many will fall asleep on express runs where there is a long interval between stops; while, in the summer when the windows are open it is seldom that a passenger falls asleep.

Per Diem Charges Are Expensive

If by delivering a cut of forty cars to a connecting carrier before midnight a crew could save $40 for its railroad, it would be an unusual set of men that would not make an effort in that direction.

If, however, one or two cars were unnecessarily held on repair tracks, or a few had been left on the line without immediate loadings, or several happened to be set on isolated sidings, or if any of a multitude of possible conditions contributing to the same result had occurred, it is doubtful whether the cars would be delivered with the least possible per diem charge.

Approximately $423,670,320 in per diem charges were paid by Class 1 railroads in 1925 and $345,492,892 received, the $78,177,428 balance being mostly rentals for private cars.

Per diem means literally "by the day." To railroaders it means the amount paid for the daily rental of a car, particularly a freight car.

The needs of commerce and the dictates of economical operation require the fast movement of freight over all roads in a through route without unnecessary transfers, which distribution scatters cars beyond the rails of their owners. To regulate the handling and return of this rolling stock a nominal rental of one dollar a day for cars away from their owning lines is made; and all carriers agree to observe the "Car Service Rules."

Per diem charges may be reduced by preventing unnecessary delays and speeding up the handling of cars, as by acquiring additional rolling stock. A per diem day is computed from 12.01 A. M. to midnight, and delivery of a car to a connecting carrier before midnight will obviate a per diem charge.

During periods of light traffic the cars "on line" should be reduced as far as possible below the number owned, which reduction will bring about a more favorable balance. When heavy traffic is experienced more cars are used than are owned, and the speedy movement of this stock is reflected in the per diem charges.

The dollar per diem rental on each foreign car unnecessarily delayed; the extra charges for crosshauling cars; the occasional neglect given cars loaded with company material; and various other conditions peculiar to the business of railroading and easily overlooked if a whole-hearted co-operation is not evident, all serve to swell the monthly per diem settlements and to increase expenses.

Proposed Metric Legislation Should Be Defeated

In the rather voluminous literature distributed by those who are favoring the adoption of H. R. 10, otherwise known as the Britten Bill, which would force the American people by law to discard our present system of weights and measures, there are many statements so completely at variance with the facts, as to almost warrant their designation as loose talk, calculated to mislead or deceive people rather than enlighten them.

Among the institutions of which we are proud is our English language and an integral part of the language is the English units of weights and measures that has served us so long, and is well suited to our present and future happiness and prosperity. There is now a well organized effort through the medium of H. R. 10, the Britten Bill, to force the American people to adopt the metric system of weights and measures, which may be well suited for certain lines of our varied activities, but is not in the circumstances as well suited for general use as the system we have always used, and therefore, as a matter of right and justice should not be forced on the people by law.

As man developed from savagery and barbarism, laws also developed for the protection of people. The history of law is the history of the human race and embodies the storehouse of its experience. The legislation of a people reflects their best thought and daily life at its best, and mirrors their adopted customs, practices and usages, and reflects what is their ordinary lawful transactions. There has never been on this earth a tribe or nation, that has not been controlled by some form of law.

A noted English jurist who at the time was Lord Chief Justice of the King's Bench gave the following definition of the proposition that: "Custom makes laws."

"Custom does not make law and never did, but whenever the majority of the people of a community, section, district, municipality or state follow or adopt habits, practices and customs, that are not in conflict with recognized law, and do not operate to the injury of themselves, the community or state, then, and in that event, such habits, practices and customs have the force and effect of law, but they are not law and do not make law."

By such well grounded interpretation, the English units of weights and measures that have been so successfully used here in the United States for over 300 years is an integral part of our language, and is in substance legalized, and therefore a fundamental part of the "law of the land."

Again, Chief Justice John Marshall warned against the possibility and probability of over-zealous state and national legislative bodies enacting into law measures that on careful study would be found to infringe the rights guaranteed to the people by the Constitution, and therefore unconstitutional.

The highly objectionable features of the Britten Bill to be presented to the next Congress are:

(a) That it is wholly indefinite and ambiguous in its terms.

(b) That it seeks to completely nullify legislation already given our English units of weights and measures by both our people and our courts, while pretending to limit their application; and it takes from our people something they have and wish to retain, and would force in its place something they do not want!

(c) That the bill, if enacted into law, would unnecessarily increase taxation by creating numerous bureaus, to the annoyance and confusion of business in general.

(d) That in substance, Sections 1 and 6 of the bill would clothe a cabinet officer, who of course is not elected by the people, with a scope of authority over the habits, practices, customs and activities of the people, both individually and collectively, that is not contemplated in the Constitution, and for that alone, and much less the other reasons cited the bill should be defeated.

Liberty, true liberty as guaranteed by the Constitution, constitutes freedom properly regulated by law.

In 1793, the French government adopted the metric system. In 1866 the Congress of the United States passed without debate a permissive act, permitting its use, and legalizing transactions in which it is used, so that, if it possessed merit over our English units for some of our people, they would be free to use the metric system should it best suit their individual needs and pleasure. That was more than 60 years ago, and the people have not adopted the metric system, except in certain special fields to which it is well suited. The great mass or bulk of our people have not only spoken emphatically as to their preference, but object to having something forced upon them which they have already told their representatives they do not want!

It is a safe estimate to say that of the 41,614,248 persons, 10 years of age or over that are engaged in gainful occupations in the United States, that 80 per cent, or about 33,291,398 use the present English units daily. If the remaining 75,000,000 of our total population, of understanding age or mental condition should have the matter fairly and honestly explained to them, at least 80 per cent would vote to stand by the 60 year verdict of the American people.

To say or even imply that the only opposition to this pro-metric bill consists of a small clique of manufacturers, "composed of far less than 1 per cent of the voters," is an insult to the intelligence of the American public. That many prominent and distinguished citizens favor the use of metric system is quite true, but, it is equally true that many of the entire pro-metric group are actuated by selfish motives and are not sincere. A great number of those prominent in our industrial, financial or political life, either do not fully appreciate the real merits of our English units as an integral part of our language, commerce and national life, or their minds have been so completely poisoned against the present system as to leave them not receptive to the real facts.

Should Congress through unwise action enact this H. R. 10 into law and thereby precipitate confusion and the unnecessary expense of many hundreds of millions of the taxpayers' money, they will find that pending action by the Supreme Court as to the constitutionality of the Act, that the greatest benefits will have accrued to the host of hungry applicants for political jobs in the bureaus that will have to be created, from the taxpayers' money, for the purpose of enforcement of an objectionable law.

We cannot too strongly urge against this proposed pernicious compulsory law, and advise its proponents to stop feeling each others pulse on such a momentous question, but to ascertain the feeling of the great mass of artisans and workers who would be most vitally effected.

Supreme Court Rules Motorist Must Take Precautions at Crossings

In crossing a railroad track, a motorist is under the obligation of using every possible means of determining that no train is dangerously near even if he has to get out of his vehicle in order to make certain, according to a decision handed down by the Supreme Court of the United States, October 31, 1927.

Associate Justice Holmes, who delivered the opinion, laid down a complete rule of conduct for automobilists and others who cross railroad tracks.

The decision set aside the judgment of a lower court against the Baltimore & Ohio Railroad in favor of Dora Goodman, administratrix of the estate of her husband, Nathan Goodman, who was killed in a grade crossing accident in Whitfield, Ohio.

The decision follows in part:

"Goodman was driving an automobile truck in an easterly direction and was killed by a train running southwesterly across the road at a rate of speed of not less than sixty miles an hour. The line was straight but it is said by the respondent that Goodman 'had no practical view' beyond a section house two hundred and forty-three feet north of the crossing until he was about twenty feet from the first rail, or, as the respondent argues, twelve feet from danger, and that then the engine was still obscured by the section house.

"He had been driving at the rate of ten or twelve miles an hour but had cut down his rate to five or six miles at about forty feet from the crossing. It is thought that there was an emergency in which, so far as it appears, Goodman did all that he could.

"In such circumstances it seems to us that if a driver cannot be sure otherwise whether a train is dangerously near he must stop and get out of his vehicle, although obviously he will not often be required to do more than to stop and look. It seems to us that if he relies upon not hearing the train or any signal and takes no further precaution he does so at his own risk.

"If at the last moment Goodman found himself in an emergency it was his own fault that he did not reduce his speed earlier or come to a stop. It is true . . . that the question of due care very generally is left to the jury. But we are dealing with a standard of conduct, and when the standard is clear it should be laid down once for all by the court. . . .

"We do not go into further details as to Goodman's precise situation, beyond mentioning that it was daylight and that he was familiar with the crossing, for it appears to us plain that nothing is suggested by the evidence to relieve Goodman from responsibility for his own death. When a man goes upon a railroad track he knows that he goes to a place where he will be killed if a train comes upon him before he is clear of the track. He knows that he must stop for the train, not the train stop for him."

Railroad Master Blacksmiths Association

Individual Papers Presented at the 31st Annual Convention

Locomotive Draw Bars and Draw Bar Pins

By S. Lewis, Canadian National Railways

Draw bar and draw bar pins on the Canadian National Railways are made and maintained according to maintenance and regulation instructions. These instructions are imperative all over our system and are a decided improved step towards a standard practice which spells efficiency and economy. These standard practices are absolute while in vogue but can be changed at intervals through regional meetings. Material for draw bars and pins is specified as to carbon content, which is very low, and the material adopted is of such quality that it will stand frequent shocks, vibrations and blows, and that without any sign of rapid fatigue.

A Word About Specifications of Draw Bar Material.—From 5 to 15 per cent carbon is specified and with a rigid inspection of this quality of low carbon steel we get very near to what is asked for. One may ask why we use this kind of steel for draw bars which is almost next to iron. Is it because it's cheaper or because it can be welded with a measure of safety? We are certain it is not because of its tensile strength. The deciding factors which control the quality of material to be used on locomotives I believe should be the service called upon for draw bars and pins to do. Well, what is the service or duties of draw bars and pins? We know that draw bars are subjected to stresses, that of tension, compression and severe shocks and vibrations, and the factor of safety used particularly here is extremely high and for this reason high tensile strength is not so essential in the material.

I am thoroughly convinced that iron has the sustaining factors of life properties greater than steel and has a greater resistance to fatigue, particularly so when we remember that resistance to fatigue or failure is not the function of static strength, for this reason I am sure that you will agree with me when I say that iron is far more preferable than steel in draw bars.

Why Iron Is Not Specified.—On Canadian railroads it is difficult to procure iron billets of dimensions suitable, and to work the shingle process in the forge shop would be just as difficult because it is hard to find scrap iron of sufficient quantities to establish such practice.

On the Western Region we have three sizes of billet steel in stock that will take care of any size bar required for the various classes of engine. After heating, the billet is drawn down in the center to length, the ends are cut down by the shape cutting machine and the holes are drilled; safety bars are handled in the same manner with the exception that the holes which are of a larger dimension are cut out by the shape cutting machine, then they are normalized, inspected and stamped, ready for service.

How Draw Bars Are Repaired and Maintained.—When the holes in the draw bar show wear and sufficient material remains at the end to allow the bar to be standard, the hole is upset on an upsetting machine and the hole drilled out to size: care is taken to examine the material around the eye as to its soundness.

Welding Draw Bars Is Prohibited.—The general principles laid down to carry out this work are—that there must be sufficient strength in draw bars and pins to stand the pull of the locomotive and sufficient additional strength to stand unusual shock, and also proper distribution of metal around the eye to make the strength of the bar practical all over.

Pins must be of proper strength to withstand the same load as the draw bar and large enough to allow a reduction in wear to a minimum. Offsets in draw bars are condemned and the practice of offsetting draw bars for the convenience of quick exchange of tenders has been actually abolished.

Why Draw Bars Are Not Welded.—There would be a lot of silly notions abandoned if a little time was devoted to study and reading of metallurgy, which really is a branch of applied chemistry. Science has traveled very far into this important question of welding; it can tell us and show very clearly what has happened or will happen when two pieces of steel of any carbon content are welded under any condition, whether in the laboratory or the forge with coal. The skillful eye of the microscopist can determine with absolute certainty whether a weld is perfect or not, for in a perfect weld there is no visible joint, the portions of crystals are the same in both pieces, and unless the crystals become common in the two pieces, there has been no weld. Welding in the forge is one of the most important operations that the blacksmith is called upon to perform and is worthy of consideration; in the face of so much talk of welding draw bars, side rods and main rods, to see if science can really dispel some of the mistaken notions about this important operation, it is common knowledge to all of us that iron or steel has a great attraction or affinity for the oxygen in the air and when iron or steel is heated a fixed quantity of this oxygen combines chemically on the outside whether it be iron or steel used, and a new substance is formed which has none of the characteristics of either of the elements. It is called oxide of iron and is one of the most menacing phenomena to encounter in welding; and if found between welds in any quantity, it causes an unsound weld. If it were possible to keep two pieces of iron or steel in a non-oxidizing atmosphere even for the time taken to place the pieces under the steam hammer or anvil, the attack is so great that it will leave its mark on the weld, particularly so if there is any delay in the performance. Some welding tests have been carried out with steel ranging from 0.1 per cent to 1.4 per cent carbon, but they were placed in a porcelain tube and were heated in an atmosphere of hydrogen gas. Such remarkable feats convey the lesson to us all of the possibility, but there are essential conditions which are necessary before this can be accomplished which are not as yet developed in any railroad shop. When this former statement is made about welding, I would not like any person to infer from said remarks that no welding can be done in an efficient manner.

This is merely to show what is happening where a weld of any description is being made. In order to overcome the attack of oxygen that is in the air on the metallic surfaces of two pieces of metal just about to be welded and when the temperature is sufficiently high, yet lower than that at which the metal would begin to melt or burn, there is one thing in practice which a great many people do not understand clearly with regard to its true function when applied, and this is the flux, be it sand, borax or some other mixture, where we use flux of any kind when making a weld. An explanation of what really takes place should be of considerable interest and value, and let us do that in a non-technical way without using any chemical terms.

When we use a certain quantity of flux, be it borax, sand or some other compound, when making a weld, this flux combines with the same amount of oxide of iron into a fusible compound called by name (ferrous silicate) and the metallic surface of the pieces to be welded are protected not only from actual burning but also from loss due to further oxidation; it acts in reality as a varnish which prevents the oxygen of the air from attacking that part which is about to be welded. It is quite possible to weld iron or soft steel without using any kind of flux, but it is very difficult to testify as to elimination of impurities between the welds. It considerably lessens the risk of reaching the danger zone to use flux and should be regarded as indispensable in welding any kind of a weld.

In making a weld, do not think for a minute that a flux, that greasy-looking substance which flows over the surface of the two parts to be welded, helps in any way to stick the two parts together. This ferrous silicate, or greasy substance, must be got rid of and if not swept off, the scarfs should be of such shape that they will easily allow a discharge of the ferrous silicate when hammering under a steam hammer or the anvils. The analogy is quite proper when we say that applying soap to your hands and face is a means to an end, but you are not clean until the soap is washed away again,—so with any kind of flux used for welding.

I do not wish at this time to go any further into details of the chemistry or art of welding, but being one of the most interesting and profitable of subjects that this convention could talk about, I hope that at our next convention there will be a paper dealing specifically with this subject and that by some of our most experienced members.

Repairing Locomotive Frames

By R. L. Woodrum

Since the making of new frames has become a lost art, I wish to confine my paper to the repairing of frames only.

As the frame proposition in railroad repair shops has become of such vital importance, as the motive power has increased in size, and as most railroads are limited to a certain number of locomotives to handle their traffic, every effort must be exercised to keep the power in service, and the blacksmith foreman comes in for his share of the responsibility; and to meet this constant demand for efficiency we must adopt the best possible means of handling this line of work.

The question of dismounting frames from the locomotive and taking to the smith's shop for repairs has also become an obsolete practice in most shops. I have sat on the floor of the meetings of this convention in years past and listened to the papers read and to the discussions on the subject of frame repairs in which some of the members advocate taking down the frames and taking to the smith's shop to be welded, stating that any other method was a makeshift job. I want to say to the members of this association that to weld frames in place is not a makeshift job, and it behooves us to get busy and apply our brain and craftsmanship to the art of making the necessary repairs to frames while in place on engines.

In our shop at Clinton Forge, Va., we have the Thermit welding outfit, the electric welding and the oxy-acetylene method. We have made a few welds with the oxy-acetylene method, but have almost entirely discarded this method of welding frames and depend entirely on the electric and the Thermit welding. It depends on the location of the fracture as to which method we employ. If a frame is broken in the top rail between the pedestal jaws, we use Thermit; if broken in the lower rail or pedestal legs, we use the electric welding process. In making a weld, no matter which method we employ, it is very essential that the greatest care is taken in preparing the frame for the weld. I will also state that it is better to jack or wedge the frame apart a fraction more than is necessary for contraction for the reason that it is better to have a small amount of compression strain than to have any contraction strain after the weld is made. We feel that we have been very successful with our method of making repairs to frames for the reason that we have had a very small per cent break in the weld.

In building up worn places caused by driving box saddle equalizers or strap spring hangers, we grind the worn places to a bright surface and use the electric process for building up.

The Use of Pulverized Coal for Fuel

The use of pulverized coal for marine and locomotive operation has at various periods been used with such degree of success as the practicability of the mechanical devices employed may have established. Several years ago pulverized coal or powdered fuel was introduced for locomotive operation on American railways but for various reasons did not come into use.

The expense of installation, plus certain objectionable features from an operating standpoint, having evidently outweighed apparent economics in cost of fuel per unit of service.

A recent installation of a pulverized coal burning system to a Shipping Board boat that will operate in the North Atlantic trade was made by the Peabody Engineering Company. It was our privilege through the courtesy of the manufacturers and chief engineer of the Steamer Mercer to examine the equipment while in operation at the docks. The system functioned satisfactorily throughout, and we will be interested to know the degree of economy obtained in regular full capacity service, which will serve as a guide to its potential possibilities in stationary and other engineering fields.

The pulverized fuel equipment, which was installed after experiments by the Shipping Board and the Navy Department, involves a bunker arrangement, conveyor for bunker fuel, pulverizer, distribution of pulverized fuel to each furnace and burner equipment. Both the bunker arrangement and the conveyor system are designed to reduce to a minimum the man-handling of coal. This will result in reducing both the operating wage and the subsistence cost.

The arrangement provides a daily supply bunker above each pulverizer, into which is fed a fuel supply for twenty-four hours. This coal is carried up from the main bunkers by endless chain conveyors and discharged into a crusher. Large lumps of run-of-mine coal are broken to a maximum of 1½ in., and the crusher discharges by gravity into the daily bunker. This in turn discharges by gravity into the feeder for the pulverizer mill. Crusher and conveyor are designed for filling the daily bunker in about two hours, leaving the remainder of the time for the coal passers to trim fuel from coal pockets to the conveyor feed hopper.

Two pulverizers, each with capacity of 3600 lb. an hour, permits the vessel to operate on one, with the other as stand-by. In operation, however, it is planned to run both mills at half load, grinding the coal finer. This degree of fineness has a definite bearing on the efficiency of combustion. A slow-speed ball tube mill is used, resulting in lower maintenance charges, it is believed, than with a high-speed mill.

A blower draws coal from each mill into a common distributor. This divides the single coal and air stream into three streams, one for each boiler. Each of these in turn divides into three smaller streams, one for each burner. The distributor is a vertical four-bladed paddle wheel operating in the coal and air line and mixing up the coal and air into a homogeneous mixture.

Burner equipment is of the turbulent type. It is a combined coal and oil burner and register, permitting the vessel to change over from one fuel to the other almost immediately, if required. This will make it possible to light the furnaces with oil or to operate the vessel in port with oil or while manoeuvring, if found necessary. It is expected to develop the pulverized coal system, so that this arrangement may not be needed, but the initial installation will have this precaution.

Bunker fuel of about 14,450 B.T.U. a lb. may be compared with oil at 18,300 B.T.U. Allowing 3 per cent differential for the cost of preparing the coal for atomization, it will require 1,306 lb. of coal to do the work of 1 lb. of oil. Oil at $1.75 a barrel is $11.60 a ton, compared with $6. a ton for coal. This means that the fuel cost for the pulverized coal burner on equal power would be about 67½ per cent. of that for oil. The saving at sea should be about $100. a day.

Various alternative calculations have been made on the basis of using cheaper coal of lower heat value, and allowance has been figured for three coal passers, which later may be reduced to two. The various daily estimated savings range from about $85 to $139.

Passing from the marine and stationary fields to that of rail transportation, it is interesting to note advice from abroad, that the German State Railways have in contemplation rather extended use of a low grade of coal, that, in the absence of more specific detail may be comparable with our large deposits of lignite.

It will be of interest to railway men in this country to learn what degree of success this experiment may have. The fuel bill for Class 1 railways is approximately $440,000,000 per year or about 9% of total operating expenses, consequently there is keen interest in any plan or systems that would result in materially reducing this major item of expense.

Railway Capital Expenditures and Equipment Performance

Increased Efficiency From Equipment

During the past seven years, or from 1920 to the end of 1926, the capital input of railways aggregated $5,200,000,000 according to a recent report of the Bureau of Railway Economics. During the first nine months of the year of 1927 as indicated in the detailed table below, the total new investment was $570,000,000 while the indications for the year are a total capital outlay of approximately $750,000,000. This will make an eight-year total of nearly six billions of dollars.

Summary figures for capital expenditures for the first nine months of 1927 follow:

ITEM	*Capital Expenditures, nine months ended Sept. 30,* 1927	1926
Equipment:		
Locomotives	$53,721,000	$72,324,000
Freight-train cars	104,565,000	143,265,000
Passenger-train cars	31,383,000	43,403,000
Other equipment	15,323,000	12,031,000
Total equipment	$204,992,000	$271,023,000
Roadway & Structures:		
Additional track	$108,002,000	$124,084,000
Heavier rail	35,199,000	29,531,000
Additional ballast	10,669,000	12,059,000
Shops and engine houses	28,102,000	29,115,000
All other improvements	183,251,000	163,281,000
Total rdwy. & struc.	$365,223,000	$358,070,000
Grand Total	$570,215,000	$629,093,000

Comparing the first nine months of the current year with the corresponding period of last year, capital expenditures for all purposes have declined by $59,000,000, or about 9 per cent. Expenditures for roadway and structures slightly increased, there being declines in expenditures for track, ballast, and shop and engine houses, but increases in the items of heavier rail, and "All other" improvements.

Capital expended for new equipment decreased by $66,000,000, or about 24 per cent.

The carry-over of authorizations in effect on October first was smaller this year than last by $120,000,000, which indicates a reduction in capital expenditures during the remaining three months of the year, as compared with the last quarter of 1926.

Based upon these indications, it is estimated that railway capital expenditures for the year 1927 will amount to an aggregate not far from $750,000,000.

As a result of these capital expenditures, and as a further development of the program to improve efficiency inaugurated in 1923, the railways this year have continued setting up new records with respect to various operating factors. Outstanding achievements of this type have been as follows:

Based on the first eight months of each year from 1923 to 1927, car-miles per freight car-day exhibit an almost continuous increase, from 27.4 miles in 1923 to 30.0 miles in 1927.

Net tons per freight train have shown an almost consistent increase from 716 tons in 1923 to 778 tons in 1927.

Freight train speed has risen consistently, from 10.8 miles per hour in 1923 to 12.3 miles in 1927.

Gross ton-miles per freight train-hour have increased continuously and markedly, from 16,464 in 1923 to 21,768 in 1927.

Fuel consumed per thousand gross ton-miles in freight service has declined steadily, that is, has improved, from 163 pounds in 1923 to 130 pounds in 1927; in the passenger service, fuel consumption has also shown progressive improvement, from 18.4 pounds per passenger train car-mile in 1923 to 15.4 pounds in 1927.

All these comparisons are for eight-month periods in the respective years.

EQUIPMENT PERFORMANCE

Adequacy of railway equipment to meet possible future increase in traffic demands is a subject open at all times to economic analysis. Light is thrown on this problem by the situation that has existed during recent months in relation to railway equipment, its physical condition, and its performance.

The week of peak carloadings occurred this year during the month of October. At the middle of that month, the situation as to *freight* locomotives was as follows:

	October 15, 1927
Number of locomotives in freight service......	32,226
Number stored	3,214
Number under repair	4,620
Number "active" (excluding stored and repair)	24,392
Ratio stored to "active"	13.2%

These 24,392 "active" freight locomotives handled the peak loading in October without difficulty, and with an actual margin of 3,214 stored freight locomotives, or 13.2 per cent of the active number, ready to be called upon in case of any increase in traffic. This was the margin of safety *at the peak*. It does not take into account stored passenger locomotives to the number of 1,233 in October, which have been and can be utilized for freight service if the traffic demands it. Nor does it include 954 switching locomotives in storage during the same month, some of which were also potentially available for freight service.

The corresponding margin of stored over "active" freight locomotives averaged 15.4 per cent during the first ten months of 1927, and rose as high as 18.7 per cent on the date (August 1) when the margin was greatest. The carloadings, at this time of greatest margin, were running considerably above one million cars per week.

Similar calculations may be made for freight cars. The car situation at the middle of October, when traffic was highest, is set out in the following table, which includes railroad owned and controlled freight cars.

	October 15, 1927
Number of freight cars................	2,418,842
Number of surplus cars................	158,437
Number under repair	137,621
Number "active" (excluding surplus and repair)	2,122,784
Ratio surplus to "active"	7.5%

In other words, *at the peak of loading*, the freight car situation offered a margin of safety of 7.5 per cent against a possible increase in traffic. The corresponding margin for the first ten months averaged 13.3 per cent, rising as high as 17.4 per cent in January.

The respective margins, as measured by the available surplus of freight equipment at the traffic peak of 1927, are indicated by these percentages of 13.2 per cent for freight locomotives and 7.5 per cent for freight cars. The locomotive margin at the peak could handle additional carloadings of nearly seven million per year. The freight car margin at the peak could similarly handle additional loadings of nearly four million cars per year. That is, the respective margins would take care of these numbers of additional cars loaded, with equipment that was in service and in good order during the month of October.

In addition to these margins, attention has already been directed to the 1,233 passenger locomotives and 954 switching locomotives in storage at the time of peak loadings. The freight car margin does not include an unusual number of cars loaded with railroad coal and held under storage. This number averaged 25,000 cars above the corresponding figure for the preceding year. The margins of safety have thus been computed on a very conservative basis, and make no allowance for further possible reductions in the number of locomotives or cars under repair.

Still another phase of the question of adequacy of freight equipment demands attention. The ratios here presented as to the available margins of freight locomotives and cars are computed on the assumption that no increase will take place in the performance of the average locomotive or average freight car. But these factors have been increasing over a period of years, and it is reasonable to suppose that similar increases may continue in the future.

In the case of freight locomotives, for example, the following relative increases in performance per pound of tractive power have occurred since 1923. The performance is stated in terms of gross ton-miles per pound of tractive power, as that represents the actual physical work accomplished by the locomotive. The figures in the following table are only relative, the average for 1923 being taken as equivalent to 100 per cent.

	Gross ton-miles per pound of tractive-power—freight
1923	100.0%
1924	94.7%
1925	102.4%
1926	108.8%
1927 (8 months)	110.2%

As to freight cars, not only is the capacity per car and in the aggregate increasing, but from 1923 to 1927 there occurred an increase in the net ton-miles of freight traffic per ton of capacity. Much more important than these factors is the fact that the mileage per freight car per day has been mounting since 1923, as indicated in the following table. Here, too, the figures are relative, the average for 1923 being taken as 100 per cent.

	Miles per car day
1923	100.0%
1924	96.4%
1925	102.5%
1926	109.4%
1927 (8 months)	110.8%

These increases in performance per pound of tractive power and per freight car day since 1923, 10.2 per cent and 10.8 per cent, respectively, indicate an added service equivalent to one-tenth of the total loadings for a year, or approximately five million cars, due to increased performance alone.

The increased locomotive performance since 1923—not per unit, but per *pound* of tractive power—would have added virtually one-tenth to the available motive power, even had there been no increase in the aggregate units of power. Similarly, the increased performance per freight car per day, since 1923, has had the effect of adding one-tenth to the available supply of cars, regardless of increase in the number of cars actually in service. To the extent that these performance factors show improvement in the future, the margin of freight equipment over that actively employed in handling traffic will tend to increase.

In other words, it is not only the number of units in service that count, but also the extent to which each unit of power or of capacity is intensively utilized.

Present, Past and Prospective Fuels

A Paper Presented to the American Society of Mechanical Engineers

By Prof. S. W. Parr

A popular bit of fiction of some 50 years ago depicts a fond and indulgent uncle left in charge of his two diminutive nephews who had a strongly developed inquisitiveness, or let us say, an over-grown spirit of investigation. Among the many interesting incidents set forth there is one in which the uncle one day showed the youngsters the interior mechanism of a watch and from that time on they had an insatiable and insistent desire to "see the wheels go 'round."

It is Dryden who says that "Men are but children of a larger growth," and it is probably quite within the bounds of truth to say that in our modern civilization, dominated as it is by industrial activities, we "want to see the wheels go 'round" for reasons that range all the way from curiosity and interest in the spectacular, to bread-and-butter requirements of every-day living.

Now here are two or three fundamental propositions which time and place at the moment permit only to be given in bare statement. You can do your own hunting for verification, or disagree to such extent as you choose. But in the main there is truth in the following statements:

1. If the "wheels go 'round" it is a form of motion the initial impulse of which is molecular, and emanates in its original inception from some form of chemical action.

2. In the planetary system of which we are a part, the greatest center of chemical activity is the sun, but at the present moment, and probably for some 2000 years to come, that particular reserve of molecular activity will hardly be able to compete with other sources of initial or elementary motion more conveniently located.

3. The most abundant as it is also the cheapest reserve of potential activity of a chemical sort resides in the stored-up energy acquired thru geological ages, in the form of hydrocarbon compounds which in our every-day speech we refer to as coal and oil. Here again, the sun may have had a great deal to do with the storage process; however, that does not alter, but rather emphasizes, the general proposition.

The temptation is great just here to expand the idea concerning the relation between cheap and abundant chemical reserves and the industries. Commerce doesn't follow the flag. It follows the molecule, provided only that there be enough of them, and of the sort to make the wheels go 'round. Commerce just now isn't gravitating with any great hustle toward the north pole. Indeed it is far more likely to head up a some remote future in Arizona or New Mexico or the center of the Sahara Desert. In our day and age nothing is more obvious than that commerce and the industries are drawn as by some unseen force into the environment or into the ready accessibility of these storehouses of potential motion which we have already referred to as the coal and oil supplies stored up by a generous past.

One of the most striking features of the case, moreover, especially to any student of natural resources, is the lavish manner in which this country of ours, and indeed this very center of industrial activity where we are assembled, has been furnished with these inestimable and I fear too little appreciated reserves of power and prosperity.

I leave it to other papers on this program to give the striking world ratios and note their equally striking significance.

We are met as a fuels conference, and at the outset we may properly set forth some further considerations relating to fuels as a whole which are general rather than specific in character. Let us, for example, very briefly review some of the salient features connected with the development of the use of fuels in general.

The discovery of coal on this continent is credited to Father Hennepin. The place was at a point on the northern fringe of the bituminous field known as the mid-continental area near the Illinois River in LaSalle County, Illinois. The record of commercial shipments from Jackson County, Illinois, by barge to New Orleans shows such activity to have been inaugurated in 1810, although too far ahead of the game to be profitable still. That event so far as the records go does not seem to have been preceded by any earlier activities from the coal fields of the eastern part of the United States.

One of the earliest accounts giving a glimpse of the fuel situation 100 years ago, may be found in an article by Marcus Bull, published as a brochure in 1826 by the American Philosophical Society of Philadelphia, and given extended notice also the same year by Professor Silliman of Yale in his journal. In this paper of Mr. Bull's we may derive some incidental information relating to fuels of 100 years ago. He has compiled an estimate of the quantity and type of fuels used by the city of Philadelphia per year, and the values he obtained were doubtless properly taken as representative for the United States as a whole. For example, out of a total consumption of fuel in the year 1826, 80 per cent was estimated to be wood, 3 per cent was charcoal, a little over 14 per cent was anthracite and less than 2 per cent was bituminous coal. Can you dwellers in industrial centers imagine a time or a populous center like Philadelphia where the sum total of smoke-producing bituminous fuel amounted to less than 2 per cent?

It must be noted, moreover, in this connection that the industrial wheels were not "going 'round" to any considerable extent at that time. In fact, there were no industrial wheels, and there were no industrial wheels because the potential power for bringing them into existence had not passed beyond the stage of discovery.

The use of fuel therefore was confined almost entirely to the supplying of household needs such as cooking and heating. The use of anthracite was just beginning to be advocated as a substitute for wood in the household. It was only 10 years before that that Fulton had made his trip on the Hudson and it was still to be 10 years before a transoceanic voyage was to made by steam. The first locomotive in America had not yet been fired up, and when it was three years later, the fuel used was wood.

This brief reference to the history of fuels is necessary, it seems to me, as a background, before we can begin to realize the progress that has been made in the 100 years just passed.

Only by the aid of such a backward glance are we able to arrive at any adequate appreciation of the phenomenal accomplishments in the utilization of fuels which have characterized the past 100 years.

If we were to enumerate some of the outstanding features which have attended this fuel development we would note:

First: *Volume*—The estimates of Marcus Bull in 1826, of 11,000,000 tons of fuel per annum for the entire United States at that time represents about one ton per capita. An estimate of the coal output for 1821 is noted from other sources of information as being 1,322 tons, all anthracite. From this status we have advanced to a total volume of 600,000,000 tons, being about five tons per capita. Of this tonnage, about 16 2-3 per cent is anthracite and the balance is bituminous coal of an estimated value at the mines of 1 3-4 billion dollars, and to the consumer with shipping charges added the annual cost would exceed five billion dollars.

Second: We should note here that the types of fuel have changed so that instead of fuels of various sorts aggregating 98 per cent of the total which were non-smoke producing as in 1826, we have arrived at a stage where the smokeless type has practically disappeared from the field and we are now consuming various fuels, over 80 per cent of which are smoke making.

Third: Advance in efficiencies has been commensurate with the enormous expansion in volume. This feature is to be credited to the engineer whose strides can readily be noted in more scientific boiler settings, improved stokers, turbine engines, pulverized coal, superheaters, economizers, and high boiler pressures. One might think that the engineer had about reached his limit, but more likely he has just made a good beginning.

Fourth: An additional characteristic which has left its mark in more ways than one is the smoke evil. This has seemed to be an inevitable result of the increase in the use of bituminous coal.

And why should there be smoke? A brief analysis of the situation may be helpful.

The ignition temperature of marsh gas is between 1,200 and 1,300 deg. fahr., a bright cherry red. Ethylene requires above 400 deg. Fahr. for ignition. These are some of the more common gaseous products evolved from bituminous coal when heated, and it is obvious that if in the process of the burning of a mass of coal, they are disengaged with an insufficient oxygen supply to complete their combustion or if while in the process of burning they strike a sufficiently cooler surface to lower their temperature below the ignition point, their function is mainly altered from heat producers to smoke producers. Now in the steam-generating plant these factors may be controlled in a very effective manner by such devices as slow and evenly distributed additions of coal or by special setting of the boiler, hence the modern mechanical stoker and the elevated or elongated boiler setting to provide both space and time for the combustion of gases before cold surfaces are encountered. So far as the steam-generating plant is concerned therefore the production of great volumes of smoke is an unnecessary extravagance, inefficient, wasteful, unsanitary and avoidable.

The case, however, with the average household or apartment heating unit is entirely different. Here the high heats do not prevail. The mechanical stokers as well as the spacious combustion spaces are absent. Moreover, the man of the house or the janitor has other duties to perform, whereupon he fills the combustion chamber to the limit and sets the dampers for a prolonged period of automatic control, during the major part of which period the so-called "heater" is simply a device for stewing off tars and vapors of inconceivable variety as to composition, odor and filth for the effective work of polluting the atmosphere. In the very nature of the case, such conditions must exist and continue to prevail in any household appliance where raw coal is fed into the furnace. No matter by what name the furnace or the coal is known, by any other name they would smoke just the same, and the worst part of the picture is not fully presented until mention is made of the fact that as a result of exhaustive studies made in many congested centers, it is demonstrated that the major part of the smoke nuisance has its origin in the domestic chimney and in the larger units of flat and apartment buildings where combustion conditions in the furnace are substantially as described above. These chimneys are guilty both because there are more of them and because they are all on the job, the entire regiment, from colonel to high private in the rear rank, with bugles and band and banners, all proclaiming the ascendency and the dominion of grime. Further elaboration of the picture would partake of the nature of supererogation.

Now what about the future? Is there any relief in sight? Will all of the next 100 years be required to undo some of the misfortunes which have befallen us along with the marvelous developments of the 100 years just passed? Some of the hopeful features of the case are the following:

1. Public intelligence is growing. This Fuel Conference is sufficient confirmation of the fact.
2. Scientific and investigational intelligence has made wonderful advance in this line in very recent years; one might almost say, in recent months. This conference will prove an excellent medium for bringing the really valuable data forward and will promote further study and specific application where the facts are shown to be sound and practicable.
3. Fuel research the world around is being promoted by both government and private agencies, today as never before. This conference should serve as a clearing house for the results so obtained with a view to their scrutiny and discussion and sifting from the standpoint of practicability and the general welfare.

Our knowledge of the constitution of coal has developed at a marked pace in the last few years. Knowledge of the underlying principles of coal carbonization has kept abreast of the fundamental data thus developed relating to the constitution of this very complex material. There are at least theoretical conditions that have been established regarding the possibility of processing bituminous coal under such conditions as will result in a solid smokeless fuel admirably suited to domestic use, a gas of high quality and sufficient volume to make it attractive to the gas maker, and a tar of considerable volume and established rating in the current markets using such material.

The question of profound interest in these passing days relates to the transfer of these facts from the realm of theory to that of practicability and established service in the industrial realms.

Let it be noted finally that the ideal fuel as a heating medium is gas. Its smokeless combustion, high efficiency, cleanliness and convenience give it a status unapproached by any other type of fuel. When it reaches the stage of volume-production to an extent where costs can be materially reduced the extension of its use will be greater than can be remotely realized at the present time. We shall welcome and encourage every agency and process calculated to promote that end. The low or even the high temperature carbonization of coal, complete gasification, improvements in the water-gas reaction, the increased demand from industrial heating, and other developments such as the Brunler engine or other applications of under-water combustion for power or evaporative purpose—these and many other possibilities now emerging, furnish a most encouraging outlook whose reduction to every-day industrial and living condition we shall certainly see consummated in the early years of the new fuel century now before us.

The future holds much promise, as there are many inviting fields for economic development of the various kinds and chemical characteristics of fuels in the industrial, marine, railway and other lines of human activity and it will be interesting to note the progress made in both the laboratory and practical use.

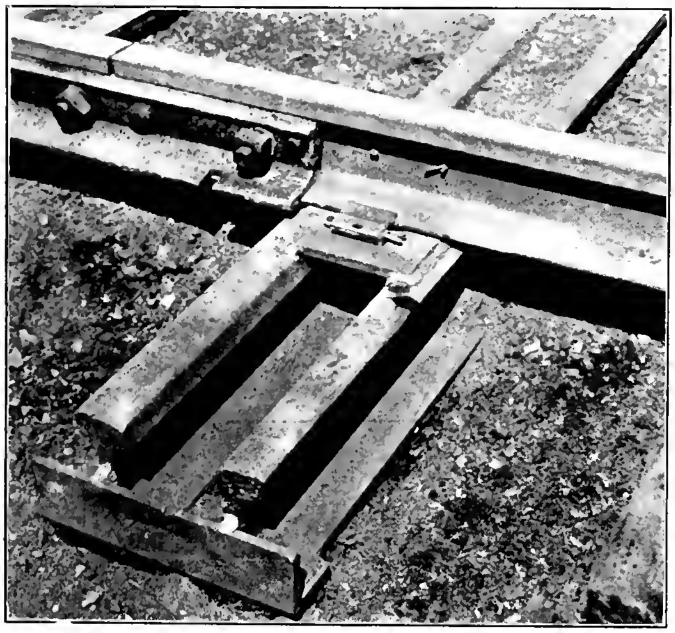
New Metal Tie Welder

Automatic welding equipment for making metal railroad ties from scrap rails is announced by the General Electric Company. By means of this equipment railroads can make their own metal ties, or manufacturers can build them for sale. The placing of this new machine on the market follows the discovery by William Dalton announced earlier this year, that this type of tie is practicable.

The metal railroad tie has advantages over the wooden tie in the way of longer life and greater strength. It is of simple construction and can be made in an automatic welding machine at low cost.

The new welding apparatus developed for this work consists of an automatic tie-welding machine and a 1500-ampere motor-generator set with two circuits for hand welding and two circuits for automatic welding. The following equipment is involved:

1. A section of a roller conveyor on which the rails are moved into position for welding.
2. A jig for correctly spacing the rails and locating the tie plates on top of the rails.
3. Two pneumatic plungers for rigidly holding these parts in position.
4. A pair of spring and toggle operated clamps for holding the angle irons against the ends of the rails.
5. A mechanism which rotates the whole jig with its rails and plates. This turns in either direction a distance of 45 degrees from the perpendicular, permitting automatic welding to be done first on one side of the tie plate and then on the other.



Welded Metal Railroad Ties Made Out of Scrap Rails on the Delaware & Hudson Railroad

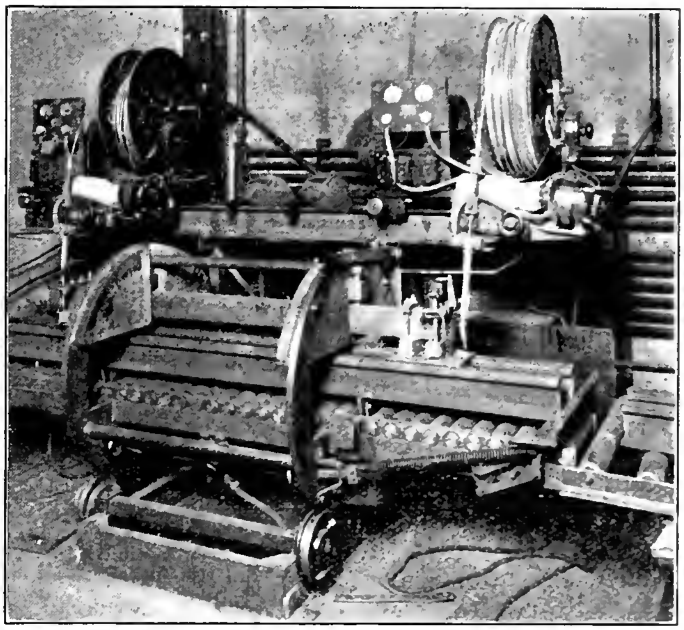
6. Two automatic welders mounted on individual travel carriages for welding the two tie plates simultaneously.
7. A track on which the travel carriages ride.
8. A supporting framework.

Each metal tie consists of two lengths of worn or scrap rail cut to length and held together at both ends by angle bars which are welded to the rails. The rails are further held together by two tie plates which are welded to the top or head of the rails at the point where the track work is clamped to the tie. The tracks are clamped to the tie plates by means of rail clamps and spring steel keys.

The actual operation is as follows:

The rails are inserted into the machine and the tie plates placed in position. The equipment is then fixed in position by means of compressed air. The angles are next placed in position, after which the work is rotated to a point where the joints between the plates and one rail may be welded. The first welds are then made automatically, the arcs moving away from each other. The fixture is then rotated to a point where the other joints are beneath the electrode and the welds are made with electrodes moving toward each other.

While the automatic welds are being made the operator welds the angles to the ends of the rails by hand welding.



Automatic Arc Welding Machine for Constructing Ties from Scrap Rails

All welding being completed, the fixture is turned back to normal position and the completed tie removed.

For maximum production the machine requires two operators, one for each of the two automatic heads. Each head has a separate control panel, thus making each operator largely independent of the other. Estimated output of the machine with two operators is one tie every five minutes.

Harriman Safety Medals to Railroads

The E. H. Harriman Gold Medal for the most conspicuous accident prevention work during this year, and probably the most coveted prize in the field of accident prevention, has been awarded to the Norfolk and Western Railroad by the American Museum of Safety.

Three medals, all first prizes, were awarded to the Class I railroads making the best showing in safety work in three groups, classified according to the number of locomotive miles operated. Group A, in which the Norfolk and Western Railroad belongs, consists of those lines which in 1926 operated 10 million or more locomotive miles. Group B comprises the railroads that operated one million to 10 million locomotive miles, and Group C the railroads with a locomotive mileage less than one million in 1926.

The first prize for Group B railroads, which is a silver replica of the Harriman Gold Medal, was awarded to the Duluth, Missabe and Northern Railway, as representing the best railroad safety record in this group. This is the second consecutive year in which this railroad has won this medal.

The safety record of the Duluth, Missabe & Northern Railroad during the past two years was reported as noteworthy. During 1925 and 1926 combined, not a person was killed, and only three passengers were injured, two in 1925 and one in 1926. The year 1926 showed very definite improvement of the high mark attained in 1925. The locomotive miles operated in 1926 totaled 1,751,000.

The first prize for Group C railroads, which is a bronze replica of the Gold Medal, was awarded to the Quincy, Omaha & Kansas City Railroad, which in 1926 operated a total of 432,000 locomotive miles, reported 628,000 man-hours, exclusive of train and engine service, and total passenger mileage of 4,994,000. During the year, no passengers were killed or injured in any class of service or any kind of accident. No one was killed at a highway grade crossing or elsewhere, and only one person, classified in the group of "all other persons," was injured. This injury occurred to a farmer driving a team across a grade crossing near Mecca, Missouri.

In addition to the three prizes, which are annual awards, the committee voted to issue a special certificate of merit to the Union Pacific Railroad. This certificate was voted as "special acknowledgement to the Union Pacific Railroad and its organization for their great accomplishment in the safety field." For two consecutive years, 1924 and 1925, the Harriman Gold Medal was awarded to the Union Pacific System. For 1926, the awards were made to individual lines, instead of to railroad systems, as formerly.

The Committee of Award of the American Museum of Safety consists of: John J. Esch, Chairman, Interstate Commerce Commission; R. H. Aishton, President, American Railway Association; Samuel O. Dunn, Editor, Railway Age; Julius H. Parmelee, Director, Bureau of Railway Economics; F. D. Underwood, President, Retired, Erie Railroad, advisor to the committee on behalf of Mrs. E. H. Harriman and Arthur Williams, Vice-President, Commercial Relations, The New York Edison Company, and President of the American Museum of Safety, Chairman of the Committee.

In discussing the awards for 1926, Mr. Williams, President of the American Museum of Safety, said that the bases of awards for 1926 were somewhat modified, as compared with the bases utilized in former years.

"Among the changes," Mr. Williams said, "were awarding the medals to individual railroads, rather than to railroad systems; passenger casualties in train accidents were rated per hundred million passenger miles, instead of per million passenger locomotive miles; casualties to 'all other persons' were rated per 500,000 locomotive miles, instead of per million locomotive miles, and suicidal or attempted suicidal casualties were excluded entirely. In addition, and following the new policy made effective by the Interstate Commerce Commission, motor train miles have been included with locomotive miles.

"The Norfolk & Western, which gets the Gold Medal for 1926, showed marked improvement in every phase of its accident situation, giving an excellent example of intelligent safety methods applied in a practical way to railway operation. In 1926 this road showed a reduction of more than 28 per cent in passenger fatalities, and a reduction of more than 14 per cent in non-fatal accidents, although having in 1926 an increase of more than 8 per cent in total locomotive miles.

"An analysis of the records of the 169 lines comprising three groups clearly indicates that safety accomplishment on our railway systems is neither accidental nor fortuitous. On the contrary, the railways that appear at or near the top of the several groups are there because they have earned the right to be there, through the application of sound principles of accident prevention to a situation always fraught with possibilities of danger."

Practically all the leading roads for 1926 show improvement over their records for 1925, while some show very marked improvement. Herein lies one of the most encouraging features of these annual medal awards made possible through the generous action of Mrs. E. H. Harriman; an incentive is presented to the lines to improve their records, to cut down accidents, and to place themselves in a position to report definite progress up the ladder toward the top.

Reduction in Railroad Accidents

The Safety Section of the American Railway Association, through the committee on education in its circular No. 167, says there is reason for rejoicing because of the splendid reduction shown in railway accidents this year.

"The average number of railway men killed monthly during the year 1923 was 169 and during the first five months of 1927 this was reduced to 121, a monthly saving of 48 lives. By the same token, the average number of non-fatal injuries to railway men was reduced from 12,685 per month in 1923 to 7,387 during the first five months in 1927, a monthly saving of 5,298 serious injuries. There is good reason to believe that the balance of the year 1927 will show as favorable progress, which will mean that for the year you will have saved 576 lives and 63,476 serious injuries among your co-workers.

"Surely those who have put forth special effort to accomplish this will feel both proud and thankful. Just as surely those (if any) who have failed to assist in this work should think seriously of their lost opportunities. Even those most callous to humanity's call must be impressed with this great boom to mankind—the greatest wastrel should appreciate the economical value of this tremendous saving.

"The committee extends to each and every railway employer and employe sincere appreciation for wonderful support during the past year. May the year 1928 be even more successful—a result that with a continuation and accentuation of your good work is inevitable.

Open Top Observation Cars

In order that passengers traveling via its Cascade route between San Francisco and Portland may enjoy the beautiful mountain scenery and have unobstructed view of the scenic wonders en route, open top observation cars have been put into effect by the Southern Pacific Company. The new observation cars were constructed in the company's Sacramento general shops from special plans designed by expert car builders. They are 67 feet, 8 inches in length; 9 feet 9½ inches wide, and have a seating capacity for 84 passengers.

Electrification Is Profitable in Switzerland

In the year 1924 the St. Gothard railway succeeded in transporting 19,000 tons of merchandise on one single day—a record which was not expected to be beaten. With the progress of electrification and a steady increase of coal transportation from the North to the South the figures of 1924 have now been surpassed. Early this year, on a single day, coal amounting to 20,000 tons was carried southward over this famous line and while Swiss railway statisticians rejoiced over this new achievement, the day following brought another procession of trains with a total of 23,000 tons of coal.

To handle this shipment 42 freight trains were necessary on the section Erstfeld-Göschenen; i.e., 18 trains of 700 to 1,000 tons each, drawn by two locomotives, and 24 trains of 300 to 500 tons each, drawn by one locomotive. At Göschenen, which is the loftiest point of the railway, 3,640 feet above sea level, trains were coupled together so that a total of only 24 trains hauled by single locomotives had to pass through the tunnel and descend towards Bellinzona.

The steam type of locomotives formerly used on this line in transporting 23,000 tons of coal in one day would have necessitated 138 locomotives and 46 through trains from Erstfeld to Bellinzona, while on the record day referred to above the 23,000 tons were hauled with the aid of 60 electric locomotives north of the tunnel and only 24 on the south side.

Condition of Rolling Equipment

Locomotives in need of repair on the Class I railroads of this country on October 15 total 8,759 or 14.4 per cent of the number on line, according to the American Railway Association.

This was an increase of 414 locomotives compared with the number in need of such repair on October 1, at which time there were 8,345 or 13.6 per cent, the lowest number ever reported.

Locomotives in need of classified repairs on October 15 amounted to 4,740 or 7.8 per cent, an increase of 256 compared with October 1, while 4,019 or 6.6 per cent were in need of running repairs, an increase of 158 compared with the number in need of such repairs on October 1.

Class I railroads on October 15 had 5,401 serviceable locomotives in storage compared with 5,720 on October 1.

Freight cars in need of repairs on October 15 totaled 135,645 or 6 per cent of the number on line, according to reports filed by the carriers with the Car Service Division of the American Railway Association.

This was a decrease of 1,926 cars under the number reported on October 1, at which time there were 137,571 or 6 per cent. It also was a decrease of 9,682 cars compared with the same date last year.

Freight cars in need of heavy repair on October 15 totaled 99,782 or 4.4 per cent, a decrease of 777 compared with October 1, while freight cars in need of light repair totaled 35,863 or 1.6 per cent, a decrease of 1,149 compared with October 1.

Equipment Installed in First Ten Months

Freight cars placed in service the first ten months this year by the Class I railroads totaled 66,364, according to reports filed by the rail carriers with the Car Service Division of the American Railway Association.

This was a decrease of 27,515 compared with the number placed in service in the corresponding period last year.

Of the total number placed in service in the first ten months this year, the railroads installed 7,659 freight cars in the month of October which included 3,133 box cars, 3,564 coal cars and 222 refrigerator cars.

The railroads on November 1 this year had 11,136 freight cars on order compared with 14,646 on the same date in 1926.

Locomotives placed in service in the first ten months of 1927 totaled 1,671 of which 195 were installed in October. In the first ten months last year, the railroads placed in service 1,839 locomotives. Locomotives on order on November 1 this year numbered 80 compared with 334 on November 1 last year.

These figures as to freight cars and locomotives include new and leased equipment.

Notes on Domestic Railroads

Locomotives

The Newburgh & South Shore Railway contemplates purchasing 4 eight-wheel switching locomotives.

The Detroit & Toledo Shore Line has ordered 4 Mikado type locomotives from the Baldwin Locomotive Works.

The Aluminum Company of America has ordered 1 Mikado type locomotive, from the American Locomotive Company.

The Algoma Central & Hudson Bay Railway contemplates buying 2 locomotives.

The Toronto, Hamilton & Buffalo Railway is inquiring for 2 Mikado type locomotives.

The Canadian National Railways has ordered 10 eight-wheel switching locomotives from the Baldwin Locomotive Works, for service on the Grand Trunk Western Lines.

The Great Northern Railway is inquiring for 4 heater cars.

The Gulf, Mobile & Northern Railway has ordered 2 Pacific type locomotives from the Baldwin Locomotive Works.

The Mexican Railway Company, Ltd., is inquiring for from 2 to 4 Pacific type locomotives through the builders.

Freight Cars

The Kirin Hauling, China, has ordered 30 box cars, 20 flat cars, 24 high-side gondola cars, and 40 low-side gondola cars, all of 40 tons' capacity, from the Koppel Industrial Car & Equipment Company.

The American Agricultural Chemical Company, New York, has ordered 3 tank cars of 50 tons' capacity for carrying sulphuric acid, from the General American Tank Car Corporation.

The Argentine State Railways are inquiring for 100 flat cars, 75 gondola cars and 25 box cars, all of 30 tons' capacity.

The Wheeling Steel Company has ordered 10 extension side dump cars of 30 cu. yd. capacity, from the Clark Car Company.

The Chicago, St. Paul, Minneapolis & Omaha Railway is inquiring for 200 50-ton gondola cars.

The Louisville & Nashville Railroad will shortly be in the market for about 2,250 freight cars and 16 passenger cars.

The Atchison, Topeka & Santa Fe Railway is inquiring for 3,850 freight cars including 1,000 box cars, 500 gondola cars, 500 refrigerator cars, 300 flat cars, 500 automobile cars, 250 double deck stock cars, 500 single deck cars, 100 Rodger ballast cars, 100 caboose cars and 100 air pump cars.

The Chicago & North Western Railway is inquiring for 100 caboose car underframes.

The Fruit Growers Express is inquiring for 600 underframes for refrigerator cars.

The Pittsburgh Railways Company is inquiring for 15 interurban cars.

The Chicago & North Western Railway is inquiring for 500 50-ton hopper car bodies, 500 70-ton hopper cars, 200 50-ton flat cars, 25 caboose cars and 100 70-ton mill type gondolas.

The Sterling Products Company, Easton, Pa., has ordered 1 rubber lined tank car, of 40 tons and 8,000 gal. capacity, for the transportation of muriatic acid. The car was ordered from the General American Tank Car Corporation.

The National Railways of Mexico are inquiring for 20 tank cars of 6,500 gallon capacity.

Passenger Cars

The Atchison, Topeka & Santa Fe Railway is inquiring for 75 passenger cars including 18 coaches, 20 chair cars, 10 three-compartment coach and smoking cars, 10 baggage cars, 10 baggage and mail cars, 60 ft. long, 3 parlor cars, 1 coach, smoking and baggage car and 1 business car.

The New York Rapid Transit Company has ordered 50 triplex units, made up of 150 car bodies mounted on 200 trucks, four trucks to each unit, from the Pressed Steel Car Company, of the same type as those ordered previously from the same builder.

The Chicago, Milwaukee & St. Paul Railway has ordered

10 steel baggage car bodies 72 ft. 9 in. long, from the American Car & Foundry Company.

The Main Central Railroad has ordered 2 combination baggage and mail cars from the Osgood Bradley Car Company.

The Hudson & Manhattan Railroad has ordered 20 subway cars, from the American Car & Foundry Company.

The Long Island Railroad is inquiring for 10 baggage cars and 2 combination baggage and mail cars.

The Texas & Pacific Railway expects to buy a number of passenger cars in the near future.

Buildings and Structures

The Baltimore & Ohio Railroad has awarded a contract to J. E. Nelson & Sons, Chicago, Ill., for the construction of water treating plants at Defiance, Ohio, and Syracuse, Ind., it has also let a contract to the Pittsburgh-Des Moines Steel Company, Pittsburgh, Pa., for the installation of a water supply system at Yoder, Pa.

The Texas & Pacific Railway.—A contract has been awarded to Gifford-Hill & Co., for the construction of a water supply reservoir two and one half miles north of Wills Point, Texas.

The Canadian National Railways has awarded a contract for the construction of a 100-ton mechanical coaling dock at Turtleford, Sask., to the Claydon Company, Ltd., Winnipeg, Man.

The Missouri Pacific Railway's own forces have started upon a program of improvement of yard and terminal facilities at Poplar Bluff, Mo., which is expected to involve a total expenditure of about $180,000. Included among the improvements are the construction of additional and longer yard tracks, the replacement of a 75-ft. turntable with a 100-ft. turntable, the installation of an additional cinder conveyor, the installation of a 100,000-gal. steel tank with necessary pipe lines and additional water columns, the construction of boiler house, etc.

Supply Trade Notes

Charles M. Schwab, chairman of the board of the **Bethlehem Steel Corporation**, has been elected president of the **American Iron & Steel Institute** to succeed the late **Elbert H. Gary; James A. Farrell**, president of the **United States Steel Corporation**, has been elected vice-president of the Institute, and **Eugene J. Buffington**, president of the **Illinois Steel Company**, has been elected a director.

E. R. Kennedy has been appointed assistant general manager of sales of the **Trumbull Steel Company**, Warren, O.

Joseph T. Ryerson & Son, Inc., Chicago, recently took over the distribution of the Foote-Burt line of drills to the railroads. Foote-Burt equipment includes machines for single and multiple spindle drilling for a great variety of work such as mud rings, flue sheets, etc.

Stearns-Stafford Roller Bearing Company calls attention to the fact that October 20th was the seventh anniversary of the installation of their roller bearings on a Michigan Central freight car. Thus, this type of bearing has a record of seven years' continuous service.

The Waugh Equipment Company has removed its New York City office from 100 East Forty-second street to 420 Lexington avenue.

The Morton Manufacturing Co., Chicago, Ill., announces the appointment of **H. B. Wilson** as Southwestern Sales Manager of the company's railroad division, with office at 915 Olive St., St. Louis, Mo.

E. N. Stevens, representative of the **Imperial Brass Manufacturing Company**, Chicago, has resigned to become assistant sales manager of the welding division of the **Bastian-Blessing Company**, Chicago.

Fred J. Fisher, Fisher Brothers, Detroit, Mich., **Clarence R. Bitting**, also of Fisher Brothers, and **Arthur W. Cutten** of Chicago, have been elected directors of the **Baldwin Locomotive Works**.

A. D. Carriger, sales manager of the pump and tank division of the **Wayne Company**, Fort Wayne, Ind., has been promoted to vice-president and director of sales for all plant divisions and will be succeeded by **W. L. Kennedy**, assistant to the sales manager.

Alfred L. Carlson recently joined the **Giddings & Lewis Machine Tool Co.**, Fond du Lac, Wis., as sales engineer, with headquarters in New York City.

The Morgan Engineering Company, Alliance, Ohio, has opened an office at 150 Broadway, New York, **E. J. Parker** is in charge.

J. J. Hennessy has opened an office at 136 Liberty street, New York City. Mr. Hennessy manufactures and distributes Hennessy journal lubricators.

M. J. Evans, formerly sales manager of the **Republic Flow Meters Company**, Chicago, has been appointed sales manager of the **Whiting Corporation**, Harvey, Ill.

William S. Miller has been appointed manager of railroad sales for the **Northwest Engineering Company**, Chicago.

The American Rolling Mill Co. has taken over and will direct the sales of the **Forged Steel Wheels Company**, whose properties they recently acquired from the **Standard Steel Car Company.**

The Standard Steel Car Company retains substantial interests in the business. Trade relations heretofore existing with them and affiliated companies will, therefore, be continued and fostered. **Harry Holiday**, formerly vice-president of the Forged Steel Wheel Company, is general manager of sales, with headquarters in Frick Building, Pittsburgh. **W. B. Quail**, formerly with Standard Steel Car Company, will be manager of sales for the Eastern District, with headquarters at 50 Church St., New York City. Chicago Sales Office will be in the Tribune Tower Building and will be under the direction of **Wm. A. Libkeman**, sales representative. St. Louis sales office is in the Railway Exchange Building and will be under the direction of Blake C. Howard, president, Equipment Sales Corporation. **C. G. Bacon**, formerly vice-president of the Forged Steel Wheel Company, will be director of research.

J. C. Whitridge, vice-president of the Buckeye Steel Castings Company, Columbus, Ohio, has been elected president to succeed S. P. Bush, resigned, and will be succeeded by J. B. Goodspeed.

The Strauss Bascule Bridge Company, Chicago, has changed the corporate name of the company to the **Strauss Engineering Corporation.**

The Hazard Manufacturing Company, Wilkes-Barre, Pa., has removed its Chicago office to 1840 Midland building, 168 W. Adams st.

L. J. Melson, who represented the **Reading Iron Company**, Reading, Pa., in the South, has been made district sales representative in the Cincinnati, Ohio, office.

The Morton Manufacturing Company, Chicago, has appointed **Mitsui Bussan Kaisha, Limited**, Tokyo, Japan, its representative for the far east, the territory including the Japanese Empire and Manchuria, China.

The Truscon Steel Company will enlarge its sash and steel window departments at Youngstown, Ohio.

The Lehon Company, Chicago, has moved its New York office from 60 Broadway to room 430, 165 Broadway. **F. T. Carpenter** will continue as eastern manager of railway sales.

Edwin S. Woods & Co., Chicago, have removed their offices from 230 S. Clark street to the Railway Exchange, 80 E. Jackson Boulevard.

R. P. Nick has been transferred from the Baltimore, Md., office of the **Lincoln Electric Company**, Cleveland, Ohio, to the Lancaster, Pa., office, in charge of the sale of motors and welders.

The Hale & Kilburn Co. and the **Six Wheel Company** have removed their offices from 30 Church street to 2104 Graybar building, 420 Lexington avenue, New York City.

The Baldwin Locomotive Works and the **Standard Steel Works Company** have removed their St. Louis, Mo., offices from the Boatmen's Bank building to the Telephone building, 1010 Pine street.

The Harnischfeger Corporation, Milwaukee, Wis., has opened a branch office at 194 Boylston street, Boston, Mass. E. J. Calder is district manager.

The Pittsburgh Forgings Company has purchased the Coraopolis plant of the Pittsburgh Knife & Forge Company, assuming all its orders, contracts, etc.

Edwin H. Lundgron, for the past four years general sales manager of the **Combustion Engineering Corporation**, New York, has been elected vice-president and general sales manager.

The Davenport Locomotive Works has been reorganized. The plant and business has been acquired and will hereafter be conducted by the **Davenport Locomotive & Manufacturing Corporation**, Davenport, Iowa. The building of locomotives, also the production of grey iron castings, forgings, boilers, machine work, etc., will be continued by the new corporation.

L. E. Lynde has been appointed manager of the transportation division of the Boston office of the **Westinghouse Electric & Manufacturing Company.** Mr. Lynde has been with the Westinghouse Company since 1920, and during the past several years has been located in its New York office where he was engaged in transportation activities. He was born and raised in Dover, N. H., where he graduated from the University of New Hampshire. He is a member of the New York Railroad Club, American Electric Railway Association and Theta Chi Fraternity. During the war Mr. Lynde served overseas as an officer with the A.E.F. where he was commander of the Motor Transport Reception Park at Soissons, France. Mr. Lynde succeeds H. S. Day, who recently resigned to become superintendent of equipment for the United Railways Company of Providence.

E. A. Thornwell, who has been established for a number of years in the railway supply and electrical specialty business, with offices in the Candler Building, Atlanta, representing in the southern territory such as the **Hale-Kilburn Co.,** Philadelphia; **Edgewater Steel Co.,** Pittsburgh, and others, has recently added the **Lincoln Electric Company** of Cleveland to his accounts. He will represent this company in Georgia and East Tennessee. At the same time, John Van Horn, factory engineer of the company, has been transferred to Atlanta as an assistant to Mr. Thornwell.

Items of Personal Interest

A. T. Miller has received promotion by the Atlanta & West Point Railroad, Western Railroad of Alabama and Georgia Railroad to the newly established position of assistant superintendent of motive power. For the past several years Mr. Miller has served these roads in the capacity of chief clerk in the motive power department, and prior to this he was with the Georgia Railroad at Augusta, in the same capacity.

W. M. Moore has been promoted on the Seaboard Air Line from assistant road foreman of engines, Virginia Division, to the position of supervisor of motor car operation, with headquarters at Savannah, Ga.

W. W. Shoemaker has been made assistant road foreman of engines of the Seaboard Air Line, Virginia Division, with headquarters at Raleigh, N. C.

A. J. Poole, for a number of years past connected with the sales organization of the Galena Signal Oil Co., with headquarters at Atlanta, Ga., has resigned to accept the newly created position of assistant to the president, in charge of mechanical matters, of the Tennessee Central Railway. Mr. Poole, prior to entering the service of the Galena Signal Co., had been in railway service for many years, his last position being superintendent of motive power of the Seaboard Air Line.

H. P. Bender has been appointed electrical engineer of the Pittsburgh & Lake Erie and the Lake Erie & Eastern Railroads with headquarters at Pittsburgh, Pa., succeeding **C. H. McConnell,** promoted.

Grover C. Carver, road foreman of engines of the Boston & Maine Railroad, with headquarters at Boston, Mass., has been appointed supervisor of rail motor cars, having general supervision over rail motor car maintenance and operation with the same headquarters. **M. E. Foster** has been appointed inspector of rail motor car maintenance, with headquarters at Boston. The position of supervisor of rail motor car maintenance has been abolished. **Albert A. Gagnon** has been appointed road foreman of engines at Boston, succeeding Mr. Carver.

Charles M. House has been promoted to superintendent of motive power and equipment of the Chicago & Alton Railroad with headquarters at Bloomington, Ill. Previous to 1918 he was employed in the engineering department of the Danville Car Company and in the mechanical department of the Alton at Bloomington, becoming general car foreman, with headquarters at the same point in 1920, a position he held continuously until his promotion to superintendent of motive power and equipment.

F. W. Hankins, chief of motive power of the Pennsylvania Railroad, with headquarters at Philadelphia, Pa., has been appointed to a similar position on the Long Island Railroad with the same headquarters.

Grant W. Stanton, traveling engineer of the Minneapolis, St. Paul & Sault Ste. Marie Railway with headquarters at Minneapolis, Minn., has been appointed master mechanic of the Winnipeg division, with headquarters at Thief River Falls, Minn., succeeding **Arthur L. Fillmore,** deceased.

C. E. Brogdon, master mechanic of the Atlantic Coast Line, with headquarters at Moncrief, Jacksonville, Fla., has been transferred in the same capacity to Savannah, Ga., succeeding **J. W. Reams,** who has been assigned to other duties. **George C. Jones,** general road foreman of engines, with headquarters at Jacksonville, Fla., has been appointed master mechanic at Moncrief, succeeding Mr. Brogdon.

Norbert J. Freiert, car foreman of the Erie Railroad, with headquarters at Buffalo, N. Y., has been appointed shop superintendent, with headquarters at North Hawthorne, N. J., succeeding **John T. Munroe,** retired.

C. James, mechanical superintendent of the Eastern district of the Erie Railroad, with headquarters at Hornell, N. Y., has been appointed superintendent of motive power, with headquarters at New York, succeeding **W. S. Jackson,** resigned. **F. H. Murray,** master mechanic of the Western district, with headquarters at Cleveland, O., has been appointed at Hornell, succeeding Mr. James.

D. C. Cossar, locomotive foreman on the Alberta district of the Canadian Pacific Railway at Medicine Hat, Alta., has been promoted to division master mechanic of the Brandon division, with headquarters at Brandon, Man. He succeeds **George Moth,** who has been transferred to the Portage division, with headquarters at Winnipeg, Man., replacing **A. M. West,** who has retired.

Albert Sutherby, master mechanic on the Western district of the Erie Railroad, with headquarters at Youngstown, O., has been transferred in the same capacity to the Mahoning division and the Kent and Akron terminals, with headquarters at Cleveland, O., succeeding **F. H. Murray,** promoted. **George T. Depue** has been appointed master mechanic and dock equipment maintenance.

Obituary

Nathaniel W. Sample, who at the time of his death was in charge of apprentices for the Baldwin Locomotive Works, died at Philadelphia on October 27, at the age of 84 years. Mr. Sample was born August 14, 1843, in Lancaster County, Pa. At an early age he entered the employ of the Baldwin Locomotive Works, which he left to enter railway service in 1871 with the Denver & Rio Grande Railroad as a machinist and foreman until 1876 when he was promoted to master mechanic. From 1886 to 1890 he was superintendent of motive power and machinery of the Denver & Rio Grande Western. In 1901 he returned to the Baldwin Locomotive Works as assistant superintendent. In the latter years of his life he had supervision of the apprentices for the Baldwin Works.

M. S. Davies Warfield, president and chairman of the board of the Seaboard Air Line Railway Company, died on October 24th at a hospital in his home city, Baltimore. Mr. Warfield was a native of Baltimore, where he was born on September 4, 1859. After his education he entered business in that city, beginning with a clerkship in a large sugar house. From this time on his business experience was in various lines, touching merchandising, manufacturing and finance. His marked ability as an organizer and leader soon became evident. His final achievement in the general business world came in 1898 when he established the Continental Trust Company, one of the leading financial institutions of Baltimore. Mr. Warfield first turned his attention to railroading in 1908, when he became a receiver of the Seaboard Air Line. Upon the dissolution of the receivership in 1912 he was elected president and chairman of the board. The general idea is that a man out of a bank doesn't have the right point of view to develop into a true railroad executive and operator.

Norman Spear Lawrence, vice-president and director of sales of the Whiting Corporation, Harvey, Ill., died on October 26 after a brief attack of pneumonia. He entered the employ of the Whiting Corporation as an estimator, becoming successively chief estimator, assistant sales manager, vice-president and director of sales. During the past few years Mr. Lawrence was also president of the Swenson Evaporator Company, a subsidiary of Whiting Corporation.

R. Spurrier Howard-Smith, formerly for many years previous to 1906, treasurer of the Link Belt Company, died on October 29, while playing golf at the Philadelphia Cricket Club, at the age of 77.

Major W. Marshall Page, vice-president in charge of sales of the Copperweld Steel Company, and well known to public utility engineers, died suddenly October 25 at Pittsburgh, Pa. For the past nine years Major Page has been connected with the Copperweld Steel Company and at the time of his death had been vice-president of the company for two years. He was also sales manager and a member of the board of directors. He was a graduate of Columbia University. During the World War he was a member of the Engineers Corps and the Chemical Warfare Division, and was retired from service at the close of the war as a Major, and with a distinguished service award. His connection with the Copperweld Steel Company followed.

New Publications

Books, Bulletins, Catalogues, Etc.

Foreign Railway Publications. The Transportation Division of the Department of Commerce has published the following railway handbooks: "Railways of Central America and the West Indies," "Railways of Mexico, Railways of South America, Part 1: Argentina," and "Railways of South America, Part 2; Bolivia, Colombia, Guianas, Paraguay, Peru, Ecuador, Uruguay and Venezuela." These publications contain detailed information with regard to development of the various railway lines, mileage, operating officials, the right of way, number of employees, motive power and rolling stock, repair shops and equipment, and also shows up-to-date railway maps of the various countries covered. These handbooks may be secured from The Superintendent of Documents, Government Printing Office, Washington, D. C., or from any of our district offices, and may be referred to as follows: "Railways of Central America and the West Indies," Trade Promotion Series No. 5, price, 70 cents; "Railways of Mexico," Trade Promotion Series No. 32, price, 50 cents; and Railways of South America, Part 2," Trade Promotion Series No. 39, price, 85 cents. Copies may be obtained from the Department of Commerce, Washington, D. C.

Roller Bearings for Railroad Journal Boxes. The Hyatt Roller Bearing Company has recently issued a bulletin in question and answer form in which the salient features of the Hyatt bearings as applied to railroad car journal boxes is given. The bulletin is illustrated, sectional views showing details of the equipment. Copies may be obtained by adressing the Hyatt Roller Bearing Company at Newark, N. J.

"Lincoln and the Railroads." One of the most noteworthy contributions to the voluminous literature on Abraham Lincoln is the book by John W. Starr, Jr., entitled, "Lincoln and the Railroads," which has just been published by Dodd, Mead & Company of New York.

The book reveals Lincoln as a pioneer railroad builder in a sense, for he was called upon to fight important and unprecedented legal battles of several railroads during the early stages of development. And, the fact that he was successful in these battles stamps him as an important figure in the growth and development of the railroads of the middle west.

In writing the book Mr. Starr spent a great deal of time and exerted much painstaking effort in collecting the material for his book, and he has produced a volume that not only depicts a new scene in the panorama of the Great Emancipator's life, but also gives some authentic and interesting sidelights on the early development of some of the western railroads.

Nema Handbook of Supply Standards. A guide book on the design, manufacture and installation of electrical supply equipment. Size 9x6 inches, 231 pages, 125 illustrations and diagrams. National Electrical Manufacturers Association, New York. Price, $3.50.

A completely revised edition of the NEMA Handbook of Supply Standards has just been issued by the National Electrical Manufacturers Association of New York City, according to D. H. Murphy, vice president in charge of the Supply Division.

This two hundred and thirty page book, which is indexed and illustrated, contains standards endorsed by one hundred and eighty-nine manufacturers of the supply division on air circuit breakers, attachment plugs, fuses, cutout bases, knife and enclosed switches, lamp receptacles and sockets, laminated phenolic products, metal molding, non-metallic flexible conduit, outlet boxes, overhead trolley line materials, panelboard and distribution boards, signaling apparatus, and snap switches, with approximately one hundred and twenty-five illustrations, diagrams of designs and methods, and numerous tables and curves.

These standards have been approved by the Standards Committee, the official body for the control of technical standardization within the Association. "This handbook represents in printed form the experience and knowledge of practical and technical men, who have for years been most vitally concerned with the design, manufacture and installation of electrical supply equipment," says C. A. Bates, Chairman of the Standards Committee, and Chief Engineer of the Bryant Electric Company.

Copies may be secured by addressing the National Electrical Manufacturers Association, 420 Lexington Avenue, New York City.

Locomotive Progress is the title of a 40 page bulletin recently issued by the Superheater Company, 17 E. 42nd St., New York. It gives illustrations and brief descriptions of recent locomotive construction such as the Texas 2-10-4 type of the Texas & Pacific Railway, the Hudson 4-6-4 type of the New York Central Lines, the three-cylinder 4-12-2 type for the Union Pacific, the Northern 4-8-4 type for the Canadian National and Baldwin Locomotive No. 60,000. Some of the specialties with which these engines were equipped are described as well as the service for which they were designed and built.

Care and Operation of the Machine Tool—By J. W. Barritt. John Wiley & Sons, New York. Price $2.75.

The book explains the construction of the various parts of machine tools, explains why and where adjustments are necessary, tells how to make them, gives directions for operating the different mechanisms properly and calls attention to the precautions necessary for accuracy, speed and neatness. The text is written in a simple and explicit manner, suitable for use by apprentices and students and for individual study.

Railway and Locomotive Engineering

A Practical Journal of Motive Power, Rolling Stock and Appliances

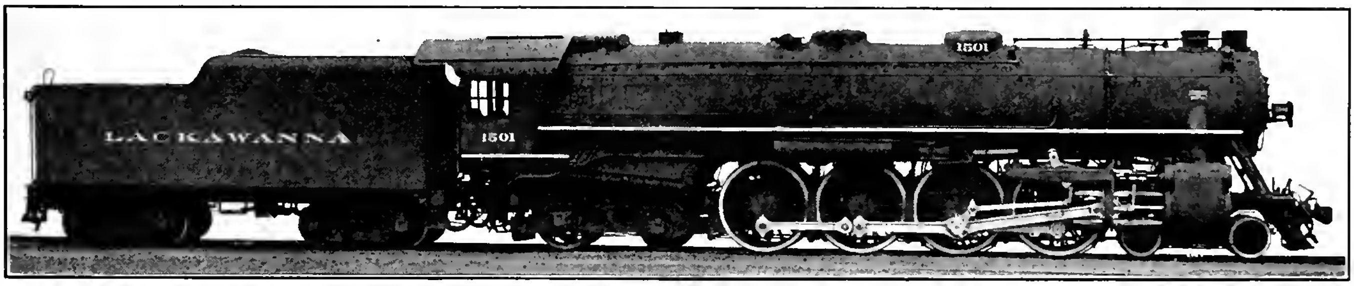
Vol. XL 136 Liberty Street, New York, December, 1927 No. 12

New 4-8-4 Type Locomotive of the Lackawanna

Designated the "Pocono" Type, They Develop 64,500 lbs. Tractive Force and Will Be Used in Fast Passenger Service

The Delaware, Lackawanna & Western Railroad has recently had delivered from the American Locomotive Company five 4-8-4 type locomotives for heavy limited passenger train service.

As an evidence that speed is a basic requirement, it should be noted that they are built with drivers 77" in diameter, as compared with previous two-cylinder engines having 69" drivers and three cylinder engines having 73" drivers. Increased tractive power is also provided as will be seen by comparing the 64,500 lbs. tractive power of these engines with previous two-cylinder engines of 58,000 lbs. and three-cylinder engines having 61,100 lbs. In tractive power they exceed locomotives of the same type recently built for the Grand Trunk Western Railway and the Northern Pacific Railway, excluding the booster in the latter case.


New 4-8-4 Type Locomotive of the Delaware, Lackawanna & Western—Built by the American Locomotive Company

These engines are built without boosters but are arranged for their possible future application. The normal maximum running cutoff is 70% but the valve gear is designed for a maximum cutoff of 85% which is made available for starting by a novel reverse lever arrangement on which the builders have applied for patent. The quadrant is only graduated to the extent of 70% cutoff but the lever may be moved farther over to give 85% cutoff but must be held by hand against spring compression. Release of the hand pressure immediately returns the lever to the position for 70% cutoff. With this arrangement provision has been made for the possible future application of the booster latch handle on the reverse lever.

In working order, these locomotives weigh 421,000 lbs. of which 269,000 is carried on the drivers, 62,500 on the leading truck and 89,500 on the trailer. With 250 lbs. boiler pressure 27 x 32" cylinders and 77" drivers, they develop a tractive power of 64,500 lbs. at 70% cutoff and have a factor of adhesion of 4.17.

The boiler is of the radial stay, extended wagon top type 84-¼" inside diameter at front and 95" outside diameter at throat. The barrel contains 50—5⅜" flues and 285—2" tubes, 21 feet 6 inches long. The Elesco type A superheater is used having 50 units. The firebox is 132" long by 96¼" inside sheets giving a grate area of 88.2 sq. ft. It is fitted with two Nicholson Thermic Syphons and an American Security Brick Arch carried on two arch tubes and the syphons. Also flexible stay-bolts are used in the throat, sides, backhead and combustion chamber. The fuel is soft coal fed by Dupont stokers. The total evaporating surface of 5,193 sq. ft. is made up of 3,194 in the tubes, 1,506 in the flues, 377 in the firebox, 28 in the arch tubes and 88 in the syphons. The total superheating surface is 1,324 sq. ft. Chamber's front end throttle valve is used in connection with Alco compensating lever to absorb expansion in the operating rod.

The main driving boxes are the Alco supplemental bearing type and all driving box cellars are arranged for narrow grease cakes of the same size as used with similar size journals on other locomotives. Front driving axle is arranged for lateral motion.

The bumpers are of pressed steel U shaped to surround a cast steel bracket housing a Miner A-18-S Friction Draft gear and short shank coupler.

The trailing truck is the Commonwealth four wheel Delta type and the engine truck is also of Commonwealth make. The top center casting extends across the frames and takes some of the cylinder and frame bolts forming a construction of maximum stiffness and materially lessening the shocks on the cylinders resulting from side movement of the engine truck and front (lateral motion) drivers.

Maximum length of main rod was obtained by designing the dish of the piston and cylinder heads toward the front.

Strombos air whistle is used located in rear of the stack.

The tanks are the Ralo Acme type on Commonwealth underframes carried on Commonwealth four wheel trucks. They have a capacity of 12,000 gallons of water and 14 tons of coal.

Other details of the locomotives are given in the accompanying table.

Table of Dimensions and Weights of the D. L. & W. 4-8-4 Type Locomotives

Type of locomotive	4-8-4
Service	Heavy passenger
Cylinders, diameter and stroke	27 in. by 32 in.
Valve gear, type	Walschaert
Valves, piston type, size	12 in.
Maximum travel	9 in.
Outside lap	1½ in.
Exhaust clearance	None
Lead in full gear	⅜ in.
Cut-off in full gear, per cent	70 per cent
Weights in working order:	
On drivers	269,000 lb.
On front truck	62,500 lb.
On trailing truck	89,500 lb.
Total engine	421,000 lb.
Tender	216,000 lb.
Wheel bases:	
Driving	20 ft.
Total engine	46 ft. 8 in.
Total engine and tender	82 ft. 2½ in.
Wheels, diameter outside tires:	
Driving	77 in.
Front truck	33 in.
Trailing truck, front	36 in.
Trailing truck, rear	51 in.
Journals, diameter and length:	
Driving main	12½ in. by 14 in.
Driving, others	11½ in. by 14 in.
Front truck	7 in. by 14 in.
Trailing truck, front	6½ in. by 12 in.
Trailing truck, rear	9 in. by 14 in.
Boiler:	
Type	Extended wagon top
Steam pressure	250 lb.
Fuel, kind	Soft Coal
Diameter, first ring inside	84¼ in.
Firebox, length and width	132 in. by 96¼ in.
Combustion chamber, length	66 1/16 in.
Tubes, number and diameter	285—2 in.
Flues, number and diameter	50—5⅜ in.
Length over tube sheets	21 ft. 6 in.
Grate area	88.2 sq. ft.
Heating surfaces	
Firebox and combustion chamber	377 sq. ft.
Arch tubes	28 sq. ft.
Syphons	88 sq. ft.
Tubes and flues	4,700 sq. ft.
Total evaporate	5,193 sq. ft.
Superheating	1,324 sq. ft.
Combined evaporative and superheating	6,517 sq. ft
Tender	
Water capacity	12,000 gal.
Fuel capacity	14 tons
Wheels, diameter outside tires	36 in.
Journals, diameter and length	6½ in. by 12 in.
Maximum rated tractive force	64,500 lb.

The Railways' Contribution to Industry in 1927

Carriers Made New High Records in Operating Efficiency

By adequate, expeditious and dependable service, the railroads have made a contribution to the industries of this country in 1927 amounting to hundreds of millions of dollars. This contribution has taken the form of savings to manufacturers and distributors, as the result of smaller inventories, quicker turn-overs and a generally increased freedom of credit, all of which have effected economies in the several processes of production and distribution.

The year 1927 has seen a decline compared with 1926 in the traffic carried by the railroads and also in their earnings, but, despite that fact, a new high record in operating efficiency has been attained. The outstanding operating records follow:

1. Condition of both freight cars and locomotives best ever reported.
2. Fewer trains and locomotives, in proportion to the amount of traffic carried, were required in 1927 than ever before.
3. The average load per train, including freight and equipment but excluding locomotive and tender, was the highest ever reported, having been three per cent greater in the first ten months of 1927 than in the same period last year.
4. The average daily movement per freight car was the highest ever attained, having amounted to 34.7 miles in October. For the first ten months the average was 30.7 miles, also a record for any similar period.
5. Freight trains were moved faster over a complete journey than ever before, the average speed between terminals having been 12.3 miles per hour.
6. Due to improvements in locomotives as well as the increase in their tractive power together with the increase in the capacity of freight cars, the average load per train and the distance carried per train-hour exceeded all previous records.
7. Freight traffic in 1927 was handled with the greatest conservation of fuel ever reported, coal consumption per thousand gross ton-miles having been 129 pounds.
8. Coal consumption per passenger-train car-mile was the lowest ever reported.
9. Most intensive use of passenger locomotives on record.

Capital Expenditures

The continued improvement in operating efficiency that has been in progress for some years is largely the cumulative result of large capital expenditures which in the past eight years have amounted to approximately 5¾ billion dollars. Through these expenditures, more adequate transportion has been provided while they have also made possible increased economy and efficiency in operation that would not otherwise have been the case. Of the total, approximately 750 million dollars represents capital expenditures made in 1927, compared with 875 million dollars in 1926.

Capital expenditures in 1927 for equipment, which includes locomotives and cars, amounted to $270,000,000 compared with $380,000,000 in 1926. The total capital outlay during the past year for roadway and structures, additional track, heavier rails, additional ballast, shops and engine houses, including machinery and tools, amounted to $480,000,000 compared with $495,000,000 during the preceding year.

Freight Loadings

From the standpoint of volume of freight traffic, 1927 represents a decrease of 1,600,000 cars under 1926 but an increase of 276,000 cars over 1925. Loadings of revenue freight for the year will amount to approximately 51,500,000 cars. This estimate is based on actual loadings for the first fifty weeks in 1927 with an estimate as to what they will be for the remaining two weeks.

Due to the anticipated strike of bituminous miners which went into effect on April 1, as well as the general stimulation in business that took place in the first half of this year, freight traffic was spread out more evenly in 1927 than ever before, with the first million-car week having been reported early in March, while heretofore such a volume of freight in any one week has never been realized before May, which was the case in 1926.

Loadings of revenue freight exceeded one million cars in 28 weeks in 1927 compared with 27 weeks in 1926 and 20 weeks in 1925. The greatest loading for any one week this year was that for October 22, for which the total was 1,128,486 cars. The peak week in 1926 totaled 1,208,878 cars which were loaded during the week ended on October 29.

Shipments of grain and grain products and merchandise and l. c. l. freight for the first fifty weeks this year showed increases over the corresponding period last year while live stock, coal, coke, forest products, ore and miscellaneous freight showed decreases.

Net Ton-Miles of Freight

Not only did the number of cars loaded with revenue freight in 1927 show a decrease under the preceding year, but there also was a decrease in the volume of freight as measured by net ton-miles, which is the number of tons of freight multiplied by the distance carried. For the first ten months, the volume of freight traffic amounted to 402,848,468,000 net ton-miles, a decrease of six-tenths of one per cent below the corresponding period last year but an increase of 6.7 per cent above the corresponding period in 1925. On the basis of actual reports for the first ten months, it is estimated that the total for the year will amount to 478 billion net ton-miles or a decrease of 10,600,000,000 net ton-miles or 2.2 per cent under 1926.

Passenger Traffic

Passenger traffic has also been running consistently below 1926, tentative reports for the year showing a decrease of approximately four per cent. With the exception of 1923, passenger traffic has been showing a steady decrease since 1920, with 1927 the lowest of any year since 1916 and approximately 27 per cent under the record year of 1920.

Net Operating Income

Due to declines in both freight and passenger traffic, net earnings of the Class I railroads in 1927 were lower than in 1926, the carriers having found it impossible to reduce expenses in the same ratio as their revenues have fallen. The rising tide of wage levels as well as the downward revision in many freight rates has proved a serious obstacle to maintaining the ratio of earnings realized last year. Had it not been, however, for increased efficiency and economy in operation in 1927, the net railway operating income of the railroads of this country would have been considerably lower than they actually were.

The net railway operating income of the Class I railroads in 1927 was approximately $1,115,000,000, or a return of 4.50 per cent on their property investment. In 1926, it amounted to $1,231,000,000 or a return of 5.13 per cent. The estimate for 1927 is based on complete reports for the first ten months which showed a net railway operating income of $942,102,322, and which was at the annual rate of return of 4.64 per cent on their property investment, and an estimate made by the Bureau of Railway Economics as to earnings in November and December. The rate of return on the basis of property investment by years follows:

1920	0.09%
1921	2.92%
1922	3.61%
1923	4.48%
1924	4.33%
1925	4.80%
1926	5.13%
1927 (Estimated)	4.50%

Equipment Condition

The railroads in the first eleven months of 1927 installed in service 72,224 freight cars. Car ownership of Class I roads on December 1 was approximately 18,464 cars, or eight-tenths of one per cent, greater than on December 1, 1923, and the average carrying capacity per car owned increased 2.15 tons per car or five per cent.

In the first eleven months of 1927, there were also placed in service 1,820 locomotives. The number of locomotives owned by Class I roads on December 1 was a decrease of 3,791 locomotives or 5.8 per cent compared with December 1, 1923, but the average tractive power increased nearly ten per cent.

Despite the decrease in the number of locomotives owned, the railroads had at no time in 1927 less than 4,600 serviceable locomotives stored in good repair which they had not found necessary to place in service.

Record in Freight Movement

Due to the faster loading and unloading of freight cars as well as the elimination of many delays in handling, freight shipments were moved with the greatest dispatch in 1927 ever attained, the average movement per freight car per day in October having been 34.7 miles. This exceeded by four-tenths of a mile the previous record for any one month, established in October, 1926. The average for the first ten months in 1927 was 30.7 miles compared with 30.4 miles in 1926.

Average Load per Car

The average load per freight car for the first ten months of 1927 was 27.2 tons, the same ah for the first ten months in 1926. The average for the first ten months this year, however, was an increase over that for 1922, 1924 and 1925 but was under 1921 and 1923. Failure of the average load per car to show an increase over 1926 was due in part to the falling off in coal shipments and in part to the larger proportion of lighter loading commodities carried in 1927. The Car Service Division of the American Railway Association through the individual roads and the various Shippers' Regional Advisory Boards is endeavoring, however, to educate the shippers of the country to the necessity for loading cars more nearly to capacity.

Cooperation of Shippers

An outstanding feature of the year 1927 was the greater cooperation between railways and shippers, exercised principally through the medium of the Shippers' Regional Advisory Boards. This movement, inaugurated in 1923, now consists of an organization of thirteen Regional Boards throughout the whole country. The Boards are composed entirely of shippers and their representatives, who meet several times a year, and serve as a forum in which railway operating matters are fully discussed. They represent agriculture, manufacturing, mining, mercantile interests, and other important industries, and their membership comprises nearly 15,000 shippers' representatives.

Some Cold Facts on the Metric System

With Some Details of the Number and Weight of the Parts of a Locomotive

By W. E. Symons

Among those who are advocating the compulsory adoption of the metric system of weights and measures in the United States, there are those who claim that it would shorten the schooling period of millions of children eight months to a year or more, and thus advance their start in life by that amount. As a matter of fact, the record shows that the entire time of the schooling period now devoted to the study of arithmetic is only about eight months. Therefore, much of such propaganda is either loose talk or an indication of lack of sincerity.

BOILER

English Dimensions in Inches

English Weight in Pounds
Metric Weight in Kilograms

Part		No. Pcs.	Dimensions Largest	Dimensions Smallest	Weight Largest	Weight Smallest	Appx. Total Wght. per Boiler
Boiler plate	English	17	262½×118½×27/32	62"×9"×⅜	7,800	60	39,700
	Metric		6.667Met.×3.01Met.×21.43 Mil.	1.575Met.×229Met.×9.525 Mil	816	27.2	18,007
Firebox plate	English	8	233×101×⅜	67½×86×⅝	2,600	600	9,800
	Metric		5.918Met×2.565Met.×9.525 Mil	1.714Met.×2.184Met.×15.875	1,179	272	4,445
Tank steel	English	25	266¾×123×⅝	25×8½×3/16	6,100	10	8,800
	Metric		6.775Met.×3.124Met.×15.875 Mil	.635Met.×.216Met.×4.763 Mil	2,767	4.54	3,992
Rivets in boiler and Jacket	English	5,000	1¼Dia.×4¾ Long	5/32Dia.×⅜"Long	2.43	.0035	3,700
	Metric		31.75 Mil. Diax×120.65 Mil. Long	3.969 Mil. Dia.×9.525 Mil. Long	1.10	.00159	1,678
Jacket steel	English	110	84×36×#18BWG	4×72×#18 BWG	42	4	2,800
	Metric		2.134Met.×914Met.×1.245 Mil	.102Met.×1.829Met.×1.245 Mil.	19.05	1.81	1,270
Lagging	English	585	39×6×2 11/16	20×6×1¾	6	2	2,200
	Metric		990.6 Mil.×152.4 Mil×68.26 Mil.	508.0 Mil.×152.4 Mil.×44.45 Mil.	2.72	.907	998
Fire tubes and ferrules	English	430	....	....	.....	.....	21,750
	Metric						9,866
Combustion tubes and ferrules and arch tubes with plugs and bushing	English	52	....	....	.....	.....	660
	Metric						299
Flexible staybolts	English	1,798	....	....	.....	.....	5,300
	Metric						2,404
Rigid staybolts	English	1,668	....	....	.....	.....	5,100
	Metric						2,313
Staybolts, sleeves, caps and nuts	English	3,846	....	....	.....	.....	2,000
	Metric						907
Brace rods and details	English	213	....	....	.....	.....	3,400
	Metric						1,542
Mud ring, tube sheet ring, sm. bx. ring	English	3	....	....	3,800	50	4,240
	Metric						1,923
Waist sheet angles	English	5	....	....	.....	.....	400
	Metric						181
Shutoff valve, drypipe, header, supports, etc	English	60	....	....	.....	.....	4,800
	Metric						2,177
Superheater pipes and details	English	1,135	....	....	.....	.....	13,250
	Metric						6,010
Washout plugs and casings, Handhole, misc. forgs. and pins	English	225	....	....	.....	.....	500
	Metric						227
Total boiler	English	15,180	....	....	.....	.....	128,400
	Metric						58,240

Passing from the educational phase of the matter to that of the artisan or worker who would be required to translate or convert the English units to the Metric in all operations, we find that some advocates of the Metric system claim that any competent mechanic could easily learn to make the conversions in a few minutes, "fifteen to thirty minutes," and that is all there is to it. It is unfortunate that Congressional Committees should have to waste their time listening to such erroneous statements. It would seem that they are not alone beyond the pale of reasonable possibility but must be classed as misleading and calculated to farther a pernicious propaganda.

Why, the average mechanic of this country could not learn to make the conversions in several days, much less a few minutes.

We are told that in the design, construction and repair of railway equipment the metric system could be used without loss of time or expense as the workers could make the conversions without confusion or delay. Such a statement must be classed with those previous cited.

Of the 41,614,248 persons over the age of 10 years that are engaged in gainful occupations, quite a fair sized proportion are employed in the manufacture or repairs of materials and machines. Of the total number so engaged, the railway companies employ large forces in their shops in the maintenance or repairs to their rolling equipment which roughly consists of the following units:

Locomotives	67,000
Pass. Cars	56,000
Freight Cars	2,412,000
Total Units	2,535,000

There is employed in the maintenance of this equipment about 525,840 men with an annual pay roll of about $770,287,736.

It is safe to say that 90 per cent of these men not only use our present English units of weights and measures many times every day and hour, as an integral part of their tools and equipment, and to talk of changing them to the metric system, without endless confusion and great loss, is simply nonsense.

To bring out this point more clearly let us take for purposes of illustration, the locomotives alone, of which there are about 67,000 and each one is composed of so many parts that an itemized list would tax the credulity of many.

It might be interesting to know the wide range of estimates of five different men we interviewed as to the total number of parts and pieces in a modern 4-8-4 type locomotive, which were as follows:

One College President	1,000 pieces
One Member of Congress	1,500 pieces
One Financier	2,000 pieces
One Railway Mechanical Officer	12,000 pieces
One Locomotive Machinist	15,000 pieces

Of the above only three, the first and last two claimed to know and of course all will be surprised and some slightly shocked when informed that there are more than 35,000.

Through the courtesy of the American Locomotive Company we are able to present herewith in tabulated form a detailed list of the pieces and parts of the modern 4-8-4 type locomotives recently built by them for the Northern Pacific Railway. A faint idea of what metric conversion involves in the construction and repairs of locomotives may be gained from the tabulations.

TANK

English Dimensions in Inches
Metric Dimensions in Millimeters

English Weight in Pounds
Metric Weight in Kilograms

Part		No. Pcs.	Dimensions Largest	Dimensions Smallest	Weight Largest	Weight Smallest	Appx. Tl. Per Tank
Tank plate	English	75	356"×90½"×5/16"	34"×5"×7/16"	3,200	22	36,100
	Metric		$9.05\text{m}\times2.3\times8\frac{\text{m}}{\text{m}}$	$8636\frac{\text{m}}{\text{m}}\times127\frac{\text{m}}{\text{m}}\times11\frac{\text{m}}{\text{m}}$	1,450	10kg	16,400
Angles	English	40	....	....	.....	.....	3,000
	Metric						1,362
Tees	English	50	....	....	.....	.....	5,000
	Metric						2,270
Rivets	English	7,350	....	....	.....	.....	2,000
	Metric						907
Valves and piping	English	250	....	....	.....	.....	400
	Metric						182
Miscel. handles and brackets	English	100	....	....	.....	.....	600
	Metric						272
TOTAL	English						47,100
	Metric						21,393

It will be noted the boiler is composed of 15,180 pieces or parts, and weighs 128,400 lbs. or more than 64 tons. The maximum and minimum sizes and weight of each plate is shown in English units with their equivalent in the metric system, from which it must be clear at a glance what is involved in the proposed change.

The metric equivalent of all other parts and pieces of the entire locomotive is through lack of space not here given, but, to those who may wish to make even a comparison we show the formula for conversion for one boiler plate. From this it can then be estimated what would be necessary in treating the other 35,864 parts or pieces in the completed unit.

For example, the size of a boiler sheet 262½ x 118½ x 27/32 inches would be converted as follows:

On reference to a conversion table we find that there are 2.540001 centimeters to one inch, so multiply 262.5 inches by .0254, as we are told the entire seven figures are not necessary and the shorter form is close enough to convert inches to meters.

262.5 inches	118.5 inches
.0254	.0254
10500	4740
13125	5925
5250	2370
6.66750 meters	3.00990 meters

We now come to the thickness of the plate which is 27/32 in., which we must convert into a decimal by the common rule. Divide the numerator by the denominator, adding to the numerator as many ciphers prefixed by a decimal point as are necessary to give the number of decimal places desired in the result.

$\frac{27}{32} = 32)\ 270.000\ (.843$
256xxx
140
128
120
96
24

Thus we find the 27/32 in., when expressed decimally is .84 hundredths or 843 thousandths or .8437 ten thousandths of an inch, but we stopped at three figures for the conversion as follows:

25.40001
.843
7620003
10160004
20320008
21.41220843 millimeters

Thus we get the result 21.43 millimeters out of the quotient of ten figures and while this is not correct, is is close enough we are told and we have at least run the proposition through the metric mill anyhow. Thus we have arithmetic calculation absorbing the time of a mechanic who is paid 60 or 80 cents an hour, making such a calculation for a single boiler plate. On a locomotive there are more than 35,000 parts or pieces that must be weighed or measured or both. If the use of the Metric system should ever become compulsory, the 12,000,000 workmen of the country would for the next few generations spend much of their time in making calculations as in the example cited.

In the construction of new locomotives all of the parts are subject to either measurement or weight and most all to both, and while it is not claimed that in repair shops, each part or piece is renewed and handled as in original construction, it is true, that with the mechanics and other workers the English units of weights and measures are just as much a part of the equipment used in the satisfactory discharge of their duties as is the case of those employed in new construction where each part or piece is originally employed in fabricating the completed unit.

The 4-8-4 engine referred to, while much larger and composed of more pieces and parts than many smaller engines now in service, yet, it is much smaller than many engines of the Mallett and Santa Fe type. Therefore, it might be a conservative estimate to place the average number of pieces or parts of all locomotives at 25,000 for each unit or 67,000 x 25,000 = 1,675,000,000 pieces or parts all measured and weighed by our English units of weights and measures.

RUNNING GEAR INCLUDING ENGINE AND TRAILER TRUCKS COMPLETE

Part	No. Pcs.	Weights English Pound	Weights Metric Kilograms
Engine Truck with Brake	200	14,100	6,395
Driving Wheels, Axles & Boxes	175	50,500	22,905
Rods & Crank Pins	165	7,650	3,473
Trailer Truck with Brake, exclud. booster	230	28,200	12,790
	770	100,450	45,563

CHASSIS

Detail	No. Pcs.	Weights English Pound	Weights Metric Kilograms
Main Frames	2	23,000	10,430
Crossties & Frame Fittg.	120	13,500	6,124
Cradle Chaf. Plts. & Drawbars	16	13,500	6,124
Cylinder, Heads, Pistons, Etc.	250	22,000	4,480
Valve Gear	200	4,100	1,860
Coupler, Drawhead, Etc.	10	1,200	544
Bumper, Steps, Etc.	14	1,800	816
Pilot, Steps & Braces	5	600	272
Guides & Yoke Ends	16	3,900	1,770
Lateral Motion	20	700	318
Crossheads	24	1,900	862
Spring Rigging	131	6,500	2,948
Driver Foundation Brake	167	7,500	3,402
	975	100,200	45,450

TENDER FRAME, STOKER AND TRUCKS

Part	No. Pcs.	Weights English Pound	Weights Metric Kilograms
Tender Frame Etc.	100	24,500	11,114
" Drawgear Etc.	25	1,000	455
" Frame Brake	150	600	272
" " Steps & Handles	20	600	272
Total Tender Frame	295	26,700	12,113
Tender Stoker	200	4,000	1,814
2-Tender Trucks, Complete	1,100	62,800	28,486
Bolts & Nuts	700	300	136
	1,595	93,800	42,549

SPECIALTIES

Part	No. Pcs.	Weights English Pound	Weights Metric Kilograms
Booster	650	10,000	4,536
Stoker	50	2,300	1,043
Live & Exh. Steam Injectors & Check Valve	230	950	431
Fire Door Oper. Rigg.	50	650	295
Air Pump & Reservoirs	300	4,000	1,814
Head Light Generator & Wiring	500	1,000	454
	1,780	18,900	8,573

MISCELLANEOUS

Part	No. Pcs.	Weights English Pound	Weights Metric Kilograms
Ash Pan & Rigging	110	3,500	1,587
Grates & Rigging	210	7,050	3,198
Cab & Fixtures	500	1,900	862
Back Head Attachments	4,000	1,000	453
Brackets, Stand & Clamps	400	700	317
Fire Brick Etc.	325	4,400	1,996
Hand Rails & Steps	115	600	272
Pipes & Fittings	2,000	3,800	1,723
Runboards, Deck, Etc.	30	1,500	680
Sand Box & Rigging	40	700	317
Smoke Stack Exh. Pipe Steam Pipes Etc.	40	2,400	1,089
Throttle Rigging	70	300	136
Tools	40	200	91
Bolts, Nuts & Studs	4,000	2,500	1,134
	7,880	30,550	13,855

SUMMARY

Part	No. Pcs.	Weight Lbs.
Boiler, Tubes, Flues, Jacket Etc.	15,180	128,400
Chassis	975	100,200
Running Gear	770	100,450
Specialties	1,780	18,400
Miscellaneous	7,880	30,550
Total Engine	26,585	378,500
Tank	7,685	47,100
Tender Frame, Stoker, Trucks	1,595	93,800
Total Tender	9,280	140,900
Grand Total—Engine & Tender	35,865	519,400

There are 526,840 employees in railroad shops on the maintenance of equipment. There are approximately the following number of different classes on locomotive work:

Machinists	60,000
Boilermakers	19,000
Blacksmiths	7,000
Helpers and Apprentices	20,000
Skilled Trades Helpers	85,000
Sheet Metal Workers	5,000
Molders	1,000
Foremen and Asst.	5,000
Equipment and Supply Inspectors	1,000
Electric Workers	6,000
	209,000

Out of a population of about 118,000,000 we have 41,614,248 over 10 years of age who are engaged in gainful occupations. 1,833,398 are employed by our railways and most all of these not only use the English language and weights and measures exclusively and they do not want any other system forced upon them.

Quite a considerable proportion of the total of 1,675,000,000 parts of our 67,000 locomotives that are in service each year and handled by the 213,000 shop men, are subject to measurement, weight, or both. In fact these shop men live, work and render service in the atmosphere of inches, feet, yards, pounds, tons, gallons, bushels, and fractions thereof. Some of these workmen employ units as much as 100 times in one day, but if we estimated their average use at only 20 times per day per man, we then find that in one year they are used a total of approximately 1,320,000,000 times.

Think of changing the thousands upon thousands of drawings, patterns, templates and other shop tools and standards without number, and then to completely change over or reeducate a people from an efficient satisfactory system of weights and measures to entirely unsatisfactory ones which they do not want. It would upset everything in the way of discipline or economy for generations to come. It is simply an exaggerated piece of nonsense to propose such a thing.

2-8-4 Type Locomotives of the Chicago & North Western

Develop 79,500 lbs. Tractive Effort With Booster

The Chicago and Northwestern Railway have recently received from the American Locomotive Co. twelve freight locomotives of the 2-8-4 type, this type having been selected as best suited to the service requirements. In the design of these locomotives, the Railway standards were maintained throughout as far as possible. As in the other 2-8-4 locomotives constructed by this Company, the Commonwealth Delta four-wheel trailer truck is used in connection with a Commonwealth cradle.

In working order these locomotives weigh 397,000 lbs. of which 253,500 lbs. is carried on the drivers, 39,000 lbs. on the leading truck and 104,500 lbs. on the trailer. With 240 lbs. boiler pressure, 28 x 32 in. cylinders and 63 in. drivers, they develop a tractive power of 67,200 lbs. at 60 per cent cut-off and have a factor of adhesion of 3.77. The Franklin Booster which drives the rear pair of trailing wheels furnishes an additional 12,300 lbs. tractive power working at 50 per cent cut-off.

2-8-4 Type Locomotive of the Chicago & North Western Railway—Built by the American Locomotive Company

The boiler is of the radial stay, extended wagon top type 86 in. inside diameter at front and 94 in. outside diameter at throat. Although intended to operate at 240 lbs. working pressure, they are capable of carrying a pressure of 250 lbs. per sq. in. The barrel contains 204 3½ in. tubes and 71 2 in. tubes 20 ft. long. The Elesco type "E" Superheater is used having 102 units. The firebox is 150⅛ in. long by 96¼ in. wide inside sheets, giving a grate area of 100.3 sq. ft. It is fitted with two Nicholson Thermic Syphons and a brick arch carried on two arch tubes and the syphons. Alco flexible staybolts are used in the throat sides and backhead. Six engines have Duplex D-1 stokers and the other six have Dupont Simplex Type B. Commonwealth cast steel ash pans of maximum capacity are used and arranged to provide an air opening equal to 180 per cent of the total tube area. The total evaporating surface of 4,872 sq. ft. is made up of 740 sq. ft. in the tubes, 3,721 sq. ft. in the flues, 288 sq. ft. in the firebox, 20 sq. ft. in the arch tubes and 103 sq. ft. in the syphons. The total superheating surface is 2,243 sq. ft.

From a shut-off valve in the dome an interior dry pipe conveys the steam to the Type E Superheater header containing the built-in American multiple type throttle. The steam to the cylinders is controlled by Walschaert valve gear arranged for 50 per cent maximum cut-off and operated by Barco reverse gear.

Main driving boxes are the Grisco type while the others are fitted with the Markel renewable crown. Six of these locomotives have Economy grease cellars. The main crank pins are hollow bored for grease lubrication. The frames are Hylastic steel and have wearing plates riveted to each pedestal leg in accordance with the Railway Co.'s practice for use in connection with shoes and wedges formed without side flanges.

The leading truck is the Commonwealth outside bearing type. Worthington Feed Water pumps are applied. Of the auxiliaries, the blower, stoker and headlight generator are operated by superheated steam.

Main rods are of the tandem type, forked at the main pin and extended to the rear crank pin.

In connection with the limited cut-off feature, a starting port is included, designed to obviate excessive pre-admission.

Patent has been applied for on the device which overcomes this common fault found in most limited cut-off arrangements. An auxiliary port formed in each valve chamber bushing leads to the cylinder barrel through a pipe, its tap into the cylinder being so located as to be covered by the piston to prevent undesirable pre-admission of steam.

The tenders, which have a capacity of 15,000 gals of water and 20 tons of coal, have Commonwealth underframes and are carried on Commonwealth six-wheel trucks with clasp brakes.

The principal details of the locomotives is given in the accompanying table.

Table of Dimensions and Weights of the Chicago & North Western 2-8-4 Type Locomotive

Type of locomotive	2-8-4
Service	Freight
Cylinders, diameter and stroke	28 in. by 30 in.
Valve gear, type	Walschaert
Valves, piston type, size	14 in.
Maximum travel	8½ in.
Outside lap	2 7/16 in.
Exhaust clearance	3/16 in.
Lead in full gear	3/8 in.
Cut-off in full gear, per cent	60
Weights in working order:	
On drivers	253,500 lb.
On front truck	39,000 lb.
On trailing truck	104,500 lb.
Total engine	397,000 lb.
Tender	287,000 lb.
Total engine and tender	484,000 lb.
Wheel bases:	
Driving	16 ft. 9 in.
Total engine	39 ft. 8 in.
Total engine and tender	82 ft. 3 in.
Wheels, diameter outside tires:	
Driving	63 in.
Front truck	33 in.
Trailing truck, front	33 in.
Trailing truck, rear	44 in.
Journals, diameter and length:	
Driving, main	12 in. by 14 in.
Driving, others	11 in. by 13 in.
Front truck	6½ in. by 12 in.
Trailing truck, front	6½ in. by 12 in.
Trailing truck, rear	9 in. by 14 in.
Boiler:	
Type	Straight top
Steam pressure	240 lb.
Fuel, kind	Bituminous

Diameter, first ring, inside	86 in.
Firebox, length and width	150⅛ in. by 96¼ in.
Tubes, number and diameter	71—2 in.
Flues, number and diameter	204—3½ in.
Length over tube sheets	20 ft.
Grate area	100.3 sq. ft.
Heating surfaces:	
Firebox	288 sq. ft.
Arch tubes and syphons	123 sq. ft.
Tubes and flues	4,461 sq. ft.
Total evaporative	4,872 sq. ft.
Superheating	2,243 sq. ft.
Comb. evaporative and superheating	7,115 sq. ft.
Tender:	
Water capacity	15,000 gal.
Fuel capacity	20 tons
Wheels, diameter outside tires	33 in.
Journals, diameter and length	6 in. by 11 in.

The Railway Station Problem

By Arthur Curran

Publication of plans for a new station to cost millions usually draws favorable attention to the road involved, and creates an impression of progress and prosperity. Very good, indeed.

It may be of interest at this time, however, to consider the methods by which the station problem has been handled abroad. For example, the outstanding difference between the American and the English way of meeting the question lies in the allocation of funds for terminal and way stations. In America it is customary to spend large sums for the former and very little for the latter; in England it is usual to provide less ornate termini and more complete and comfortable way stations.

About the middle of the nineteenth century, King's Cross Terminus was constructed. The two main arches, of which it then consisted, still stand. Additional tracks and platforms have, from time to time, increased the capacity of this famous London station; but its original character remains unchanged. On the merging of the G. N. R. into the L. N. E. R., the station became headquarters for the Scottish traffic of the combined system.


Kenilworth Station on the London, Midland & Scottish Railway

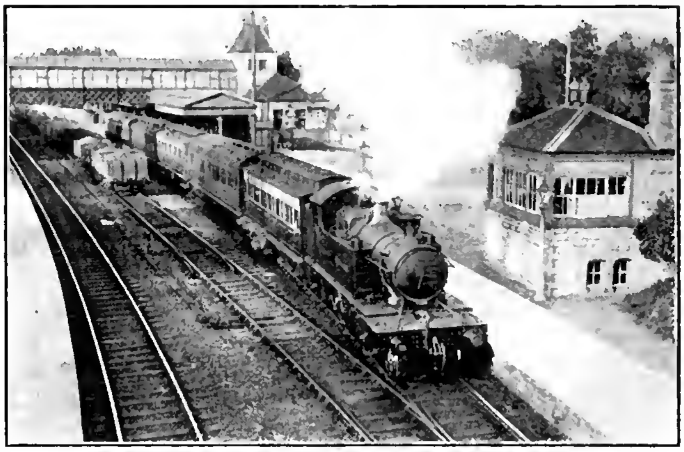
Paddington Station of the G. W. R. is another old London terminus. A series of arched train-sheds cover the tracks and platforms. The style of architecture is less severe than that of King's Cross; but the utilitarian is the dominant note in its construction.

This "note," by the way, is struck in most of the London termini, with the exception of St. Pancras, the rather ornate station of the old Midland Railway now part of the London, Midland & Scottish.

Mention of the L. M. S. suggests reference to its station at Kenilworth, illustrated herewith. Two tracks, two platforms, two brick buildings with iron and glass platform-sheds, and a foot-bridge constitute the facilities for a town of moderate size. A rather nice layout, if I do say so!

A double-track station on the Great Western Railway is also shown; though in this case there is a middle track, for storage or other purposes, protected by a derail. Incidentally, the passenger train is a local, with 2-6-2 tank engine of one of the small classes. It will be observed that there are two platforms, connected by a foot-bridge.

The attention to safety, as exemplified by these stations, may be found in America; though the practice is not so extensive here as in England. Of course, there are reasons for this; some good, and some "not so good." Perhaps the fact that so much money is spent for terminal stations in America accounts for the lack of interest in way stations. However that may be, there is a real need for a comprehensive programme of improvement along the lines suggested. American railway officers have tried to please as many people as possible. Their work has often involved the complete transformation of an undesirable neighborhood, and the harmonization of that work with elaborate civic plans. The tendency to make an amusement centre of the location of a railway terminal appears to be gaining ground, and may well introduce new problems—financial and otherwise—for the solution of which railway officers will have to search.


A Station View on the Great Western Railway

Of course, some termini projects are attractive because they include buildings that are reasonably certain of being self-supporting; and, perhaps, even highly profitable. No one wants to discourage such plans.

The point is, simply, that unless such assurance of success is forthcoming, it would be better to spend more money on improvements "out on the road." The elimination of particularly annoying and dangerous grade-crossings, would expedite train-movements and relieve enginemen of needless worry and officers of much anxiety. Motorists are not very docile, nor do many of them realize the strain which their antics put upon the workers in a great and important industry.

Then, too, the betterment at way-stations, as already suggested would do much good in a direction that has not received an abundance of attention heretofore. The aim should be a well-balanced system, as distinguished from the practice of "putting all your eggs in one basket."

On many roads, it is necessary for fast trains to stop outside way-stations because a local is discharging passengers right across the track which these fast trains must use. I am well aware of the fact that, in certain localities, this cannot be avoided; but I believe that something could be done to improve matters elsewhere.

Over in England, they sometimes locate platforms alongside of "loop-lines." This scheme serves a double purpose. First, it protects passengers who leave trains at way stations; and, second, it enables express trains to pass locals while the latter are discharging passengers. This method makes for smoothness of operation where there are but two main tracks. Very naturally, the dispatchers are well acquainted with these favorable points, and use them to perfection!

Of course, the plan calls for two platforms, one on each side of the right-of-way, and two main tracks with "loops" serving the platforms; being, in effect, a four-track station. This costs money; but is certainly cheaper than a complete four-track line, or even damage suits!

The English people show a greater respect for railway rules than Americans do, and if such plans are considered necessary in the "tight little isle," they are even more necessary here. The attempt to protect people from their own folly is often enough a losing fight, as every railroad man knows!

Let us have the imposing terminal buildings, by all means; so long as all is well "out on the road." But until some people "get religion" or "turn over a new leaf" in some other way, it will be needful to protect them from the consequences which invariably overtake those who "take a chance."

In the provision of this protection, the layout of local stations may play an important part. The problem requires careful study, but is not at all an impossible task. Relatively small sums, judiciously expended, often work wonders; especially when applied at strategic points. In any case, such a policy would result in more evenly-developed railroads.

A Narrow Gauge Railway

When we speak of narrow gauge railways we think of 3 ft. 6 in. and 3 ft., the latter to our minds being about the limit for safety. In fact, many of us shake our heads in doubt when discussing the latter, and if a gauge less than 3 ft. were mentioned to those who have grown up in the 4 ft. 8½ inch atmosphere, many would doubt its feasibility while some would condemn it outright.

When we come to talk about a regular freight and passenger railway operated with steam locomotives with a gauge of only 23½ in., some will feel that the joke is being carried too far. In the language of the astonished farmer, who when brought into the presence of a camel, declared vehemently "There Ain't No Such Animal." We present herewith some historical data and statistical information of the Festioning Railway of England.

This railway is one of four in England built to 1 foot 11½ inches gauge and is located in Wales, terminating at the seaport of Port Madoc on Cardigan Bay.

The line was built principally to handle slate from extensive slate quarries in the mountains not far inland, but does quite a passenger business, and was projected by a Mr. Spooner in 1832. The line was opened in 1836, the rails were 16 lbs. and rested on stone. It was operated with horses. In 1863 the line was relaid with 30 lb. rails on timber ties. In 1865 it was opened for freight and passenger traffic. Steam locomotives displaced the horses, and it has been continuously operated as such since that time, or about 59 years.

Some statistical data of the line follows:

Gauge	1 ft. 11½ in.
Mileage	14½
Locomotives	9
Passenger Cars	61
Freight Cars	1,215
Engine Mileage	92,598
Engine Mileage per Engine	10,288
Passengers Carried	146,011
Freight carried, Merchandise	5,238 Tons
Freight carried, Minerals	66,699 Tons
CAPITALIZATION	
Capital, Common and Debenture Stock	$765,915
Average amount per mile	54,708
Income 1923	86,370
Income per mile	5,958
Expenditures	96,490
Expenditures per mile	6,654
Deficit	6,950

This line operates through tunnels with clearance so limited that passenger car compartment doors are locked, and the wisdom of this is proven in the fact that in sixty years or longer no accident has occurred.

Many of the engines are now more than 50 years old and are still rendering good service.

Electric Motor Operation on the New Haven

The motor generator locomotives built for the New York, New Haven & Hartford by the General Electric Company and the American Locomotive Company and put into service in the summer of 1926, have demonstrated what can be expected of this type of locomotive in service not influenced by heavy grades. There are now in operation a total of seven locomotives of the motor-generator type, five of which are used in freight service between New York and New Haven, Conn., and two in switching work at the Oak Point yard. All are equipped to operate from a single-phase trolley only, as they are not used in the direct-current zone where this company has trackage rights.

Because of the extremely flexible voltage control of the main generator it is possible to start and accelerate a train smoothly and uniformly. For the same reason there is also little tendency for the wheels to start slipping whenever the locomotive is working at high adhesions.

The use of the shunted field positions in the eighth and ninth notches of the controller gives high running speeds, and for this reason the locomotives are employed on manifest freight trains. Because of the fact that the speed is practically independent of the trolley voltage the running time on the road is uniform. It has also been found that the leading current drawn by the synchronous motor is favorable as regards power factor.

The switchers have been in service on various kinds of work in the Oak Point Yard at New York. Here on account of the weight on drivers, the characteristic of quick acceleration has been an advantage, where it is necessary to make a large number of short, finely controlled movements.

In general, the operating department considers that the equipment fits into service requirements satisfactorily.

The general design of these locomotives is similar to that of the equipment already in use. The wheel arrangement of the freight engine is 1-B+B-1 and that of the switcher B+B.

	Freight	Switcher
Type of locomotive	11,000 V 25 Cycle	Single Phase M G Set
Length overall	53 ft. 2 in.	38 ft. 3 in.
Width over cab	9 ft. 10 in.	10 ft. 0 in.
Height, trolley locked down	14 ft. 10 in.	14 ft. 8 in
Total wheel base	39 ft. 0 in.	25 ft. 0 in.
Rigid wheel base	8 ft. 3 in.	8 ft. 3 in.
Total weight	280,000 lb.	211,000 lb.
Weight on drivers	220,000 lb	211,000 lb.
Weight per driving axle	55,000 lb.	52,750 lb.
Weight per guiding axle	30,000 lb.	....
Diam. of driving wheel	42 in.	42 in.
Diam. of guiding wheel	36 in.	....
Number of driving motors	4	4
Total output (Cont. rating)	1,120 Hp.	440 Hp.
Tractive effort (Cont. rating)	17,100 lb.	14,500 lb.
Speed (Cont. rating)	24.6 m.p.h.	11.4 m.p.h.
Total output (One hour rating)	1,350 Hp.	500 Hp.
Tractive effort (One hour rating)	24,800 lb.	23,200 lb.
Speed (One hour rating)	20.4 m.p.h.	8.1 m.p.h.
Tractive effort (Starting)	66,000 lb.	63,300 lb.

Annual Meeting of the A. S. M. E.

Railroad Division Reports on Progress and Locomotive Back Pressure

The annual meeting of the American Society of Mechanical Engineers was held in New York, December 5th. At the two sessions of the Railroad Division of the Society, five papers and a report of progress in the railroad industry were presented. At another sectional meeting, Mr. R. Hilderbrand, presented a paper dealing with the application of Diesel Engines to Locomotives.

The report on the year's progress in railway mechanical engineering was read by the chairman of the division, H. B. Oatley, vice-president, The Superheater Company, New York. Abstracts from some of the reports are presented on this and the following pages.

Progress in Railway Mechanical Engineering

During the past year the progress in railway mechanical engineering has been steadily toward bettering the operating efficiency of railroads by continuing the effort to increase the gross ton-miles per freight train-hour. Part of the accomplishment is due to heavier and more efficient motive power, part to improvements in signaling, heavier car loading, etc. The tendency toward higher steam pressures in locomotive boilers is going forward. The Pennsylvania is engaged in designing a 2-10-0 type with 450-lb. pressure. Auxiliaries are operated with superheated steam; enlarged grate areas and greater firebox volumes are being used in increasing numbers, as are also feedwater heaters and exhaust steam injectors. Three-cylinder locomotives are being purchased in considerable numbers. Experiments are still being conducted with oil-electric locomotives in switching service. The Chicago & North Western has added storage batteries to reduce the weight of the primary power plant.

Indications from records covering the first half of 1927 encouraged the belief that the fuel savings on locomotives will amount to approximately $17,000,000 as compared with the year 1926. The consumption per 1,000 gross ton-miles in freight service for the first four months of this year was less than for the corresponding period during the year 1926. If this rate of reduction is maintained, the 1927 figure will be 129 lb.

Back Pressure and Cut-Off Adjustment for Locomotives

By THOS. C. McBRIDE, Consulting Engineer, Worthington Pump and Machy. Corp.

Back pressure, as generally understood in connection with the locomotive, may be defined as the pressure of the exhaust steam in the exhaust ports in the cylinder saddle of the locomotive. It has been studied for years in connection with the design of details of the locomotive to the end that it might be reduced to a minimum in the interest of economical operation and increased capacity.

About three years ago, a use for back pressure in the operation of the locomotive was developed. This development followed a demonstration of the fact that the back pressure could be used to indicate the length of cut-off that should be used to obtain maximum power from the locomotive and also to avoid the waste of steam and fuel that would result from the use of an unnecessarily long cut-off. These two viewpoints, that of the designer and that of the operator, should not be confused. It is from the latter standpoint only, presuming that the locomotive has been properly designed, that back pressure and cut-off are considered in this paper.

The first complete demonstration of the principles involved with which the author is familiar is contained in a paper presented by R. W. Retterer before the International Railway Fuel Association at their meeting in May, 1925, and published in the Proceedings of that association. In that paper it was demonstrated that the power that could be obtained from the cylinders of any particular locomotive was limited to a certain definite maximum at any speed high enough to obtain that power, and that when the cut-off was so adjusted that this maximum cylinder power was obtained, the same back pressure was obtained at all speeds. The cylinder power is limited because the further extension of a cut-off already long enough, although it raises the top line of the indicator card and increases the area to that extent, also raises the bottom line of the indicator card and decreases the area to the same or perhaps a slightly greater extent; all because of the increased back pressure due to the greater amount of steam that must pass through the blast nozzle.

Mr. Retterer's paper also described an experiment with a locomotive equipped with a gage in the cab to indicate the back pressure. The piping connecting this gage to the exhaust ports of the locomotive was provided with a uniflow fitting. This locomotive and a certain train were run six times up a certain grade for a distance of 10,000 ft. The cut-off was kept so adjusted on each run that back pressures of 10, 12, 13, 14, 16, and 20 lb. per sq. in. respectively, were maintained on the back-pressure gage. A maximum speed of 27 miles per hour was obtained on the run with 13 lb. back pressure, and maximum speeds of practically 24 miles per hour were obtained on the runs with 10 and with 20 lb. back pressure. The greatest power must have been obtained with 13 lb. back pressure and less, but about the same power with both 10 and 20 lb. back pressure. The total steam used on the 10,000-ft. run was about the same for 10, 12, and 13 lb. back pressure, but for back pressures above 13 lb. the total steam used increased practically in proportion to the increase in back pressure. From this experiment it must be concluded that any cut-off which resulted in a back pressure greater than 13 lb. meant less power developed and more steam consumed—with the chance that the boiler pressure might drop and the train stall.

In order to determine more definitely the relation between back pressure, indicated horsepower, steam consumption, and fuel burned, use has been made of the bulletins published by the Pennsylvania Railroad System from their Locomotive Test Plant at Altoona, Pa. In Fig. 1 these items have been plotted as taken from the bulletin, dated 1915, which reports the test of a P. R. R. standard Mikado type L-is locomotive which had the usual standard injector equipment.

Referring first to the solid-line curves marked "injector" it is noted that:

1. The i.hp. reaches a definite maximum of 2,750, beyond which no further increase in power is to be expected, and when this maximum is reached the back pressure is 16 lb.
2. The fact that the various points indicating i.hp. fall

so close to a smooth curve indicates that maximum power is obtained when the cut-off is so set that a back pressure of 16 lb. is obtained, at least for all the speeds at which tests were made at this power. It might be expected that more power would be developed with the same back pressure at higher speed and shorter cut-off; in fact, the points plotted show a slight tendency in that direction, and in some other plots that had been made this tendency is more pronounced. The points for 100 r.p.m., it is true, are well below the curve, but the points for 80 r.p.m. which have not been plotted fall almost exactly on the curve. Even if it is concluded that, with the same back pressure, more power is developed at higher speed and shorter cut-off, it still remains true that the points plotted indicate that the maximum power for each speed is obtained at one and the same back pressure, and the usefulness of back-pressure indication of proper cut-off to obtain maximum power is not lessened.

3. The curves "steam to engine" and "dry coal fired per hour" also show points falling quite close to a smooth curve and steam and fuel consumption increasing at a rapid rate as the back pressure which represents maximum power is reached.

It is doubted whether locomotives are operated on the road for any very long periods at the excessive rates to which they are forced on the test plant, principally because of the difficulty in maintaining steam pressure. It is noted also that the last 100 i.hp. developed require 7,000 lb. of steam and 2,400 lb. of coal per hour and are obtained at an almost prohibitive cost. These two features seem to indicate that, instead of attempting to obtain the outside maximum cylinder power possible through the use of a cut-off resulting in 16 lb. back pressure, it might be advisable to use a slightly shorter cut-off, resulting in, say, 13 lb. back pressure, with the assurance that the boiler pressure would be maintained and with the avoidance of the expenditure of so much more fuel to obtain just a little more power. Here, then, the engineer should be instructed to keep the cut-off so adjusted that a back pressure of 13 lb. is obtained whenever maximum power is desired. A shorter cut-off, indicated by a back pressure of less than 13 lb., would not realize the full possible power of the locomotive. A longer cut-off, indicated by a back pressure of more than 13 lb., would not realize any more, but probably somewhat less, power developed. More steam would pass through cylinders, more fuel would be burned and this additional fuel wasted, and with a cut-off much too long the capacity of the boiler might be exceeded and the steam pressure drop.

Question naturally arises as to when or under what operating conditions of the locomotive back pressure can be made useful in its indication of the proper adjustment of the cut-off. There are roughly four different conditions of operation on the road to be considered as concerning the adjustment of the cut-off:

1. *Drifting*, when the length of cut-off is determined by mechanical and not economic conditions.

2. *Light power*, when the cut-off should be as short as smooth operation of the locomotive will permit and the speed controlled by the throttle and the length of cut-off again dictated by mechanical conditions.

3. *Medium power*, when the throttle should be full open and the speed controlled by the adjustment of the cut-off. The length of cut-off is dictated by the speed required, the steam is used economically, and nothing further is needed to assure the use of a cut-off of proper length.

4. *Maximum power and powers approaching the maximum*, when the throttle should be full open and the cut-off only as long as is necessary to secure the maximum cylinder power. It is under this condition alone that the back-pressure gage can be of use as an indication of the best adjustment of the cut-off. Modern conditions have required the operation of locomotives at maximum or near maximum powers a large portion of their time on the road. The back-pressure gage should be of great assistance in meeting this requirement.

Incidental advantages of the back-pressure gage at powers other than maximum have already been noted, but these are generally foreign to the determination of the proper adjustment of the cut-off and the economic operation of the locomotive.

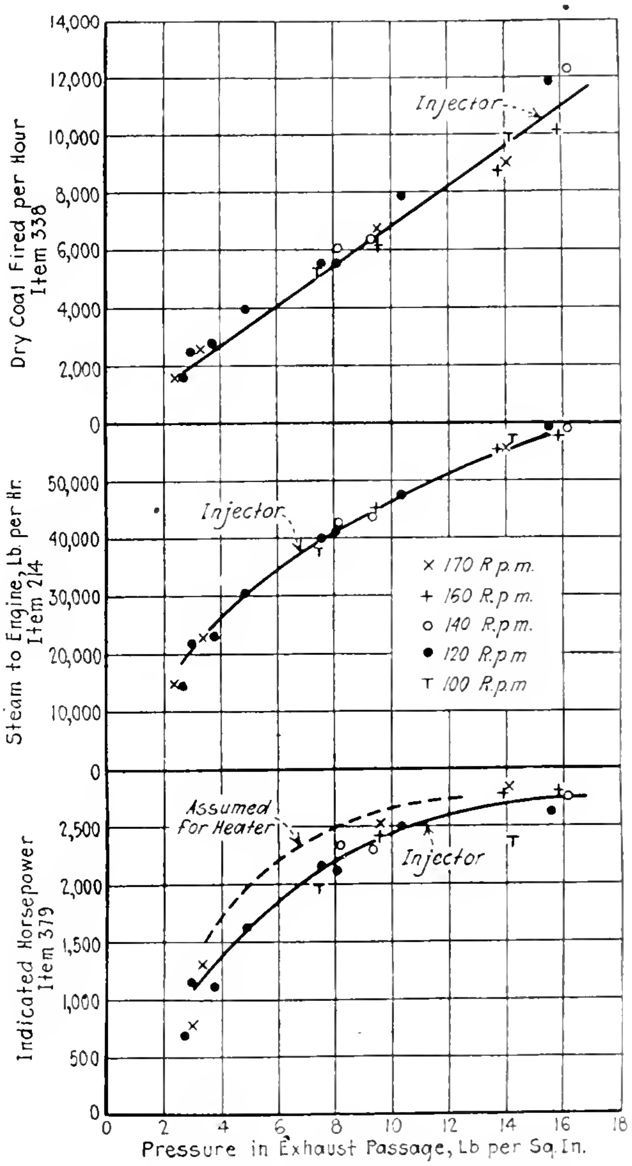


Fig. 1 Data from Pennsylvania Railroad Locomotive Test Plant
(Bulletin No. 28, Pennsylvania Railroad Co. L-1s Mikado Locomotive)

Now that there are over 5,000 locomotives equipped with feedwater heaters in service in the United States and Canada, the indications of the back-pressure gage with the feedwater heater in service demand consideration. The same, or practically the same length of cut-off is required for the same power developed by the heater locomotive and by the injector locomotive, but the back pressure on the heater locomotive is lower because of the exhaust steam taken by the heater to heat the feedwater. No tests have been made on the test plant and, as far as the author is advised, no tests have been made on the road showing comparable data on heater and injector operation of the same locomotive at powers approaching the maximum for the cylinders. It has therefore been necessary to calculate the relation between back pressure and i.hp. for the heater locomotive. This relation is shown by the dotted curve of Fig. 1. In laying out this dotted curve it was assumed that for the same power developed the back pressure obtained would be that corresponding to 15 per cent less steam than is shown by the "steam to engine" curve, inasmuch as approximately 15 per cent less steam would pass through the blast nozzle of a heater locomotive with water at the temperature of the water used in this paritcular test plant test.

It is noted from the curves that the maximum cylinder power of 2,750 i.hp. is obtained with the heater locomotive with a cut-off which results in 12 lb. back pressure as compared with 16 lb. back pressure for the injector locomotive, and that this cylinder power could be maintained with the heater locomotive because it requires 8,200 lb. of coal burned per hour, whereas the same power could not likely be maintained by the injector locomotive because it requires the burning of approximately 11,000 lb. of coal per hour. Greater sustained maximum power is possible because of the feedwater heater. The back-pressure gage properly used offers the same assurance that this greater sustained maximum power will be obtained from the heater locomotive that it presents for the obtaining of maximum power from the injector locomotive.

It is a well-known fact that there is a tendency to operate locomotives by "the sound of the exhaust," this sound at least influencing the engineer's judgment in the adjustment of the cut-off. If a heater is applied to a locomotive and the locomotive operated with the cut-off so adjusted that the exhaust sounds the same as it sounded previously with the injector, then the back presssure must be the same and, consequently, the same amount of fuel is burned with the heater as with the injector. One result would be obtained with such operation at medium powers of the locomotive and a quite different result at maximum or near-maximum powers. Referring to Fig. 1, it will be noted that at medium powers more power will be developed with the heater, which, with the same tonnage, will appear as increased speed. The same amount of fuel is burned but more power is obtained, and the heater is used to increase the capacity of the locomotive rather than to save fuel. At maximum or near-maximum powers, however, with the same sound of the exhaust and the same fuel burned, the same power would be developed. For example, referring again to Fig. 1, with 14 lb. back pressure, 2,700 i.hp. would be developed and 9,600 lb. of coal burned, both with the heater and with the injector. The saving in fuel obtained from the heater is cancelled by the unnecessarily large amount of steam supplied to the cylinders due to the use of entirely too long a cut-off with the heater. The back-pressure gage can be used to determine and demonstrate this lower back-pressure necessary with the heater if full advantage is to be taken of the heater.

Since a considerable number of exhaust-steam injectors are in service, an attempt was made to develop the relation between back pressure and power developed with them, but too many assumptions are necessary. These injectors are generally so selected as to size that the ordinary working rates of the locomotive are above their minimum capacity and their maximum capacity of the locomotive is then generally above their maximum capacity. Furthermore, the amount of exhaust steam that can be used by the exhaust-steam injector varies with the capacity at which it is worked, and the amount that is used varies with the adjustments made. The reduction in back pressure with the exhaust-steam injector in service is therefore a variable quantity that would make it difficult to interpret the readings of the back-pressure gage as an indication of cut-off adjustment.

It is evident from all of the above that if back pressure is to be used to secure proper operation of the locomotive as to cut-off, then some method must be developed to determine experimentally the best back pressure, i.e., the back pressure which results from the shortest length of cut-off that will develop the maximum power that can be maintained with each railroad class of locomotive when the speed is high enough to obtain that power. The method most used to date has been that of operation by an expert whose judgment is depended upon to determine the best back pressure. The method used by Mr. Retterer as described in his paper submitted to the International Railway Fuel Association, and briefly in this paper, obtains more exact information. Where a locomotive has been tested on the test plant the best back pressure can be determined by the method suggested in Fig. 1. Where a dynamometer car is available or in use for other purposes, simultaneous readings of the back pressure and drawbar horsepower developed could be plotted and the minimum back pressure, and therefore minimum steam consumption for maximum drawbar horsepower, thus obtained.

By these methods the best operating cut-off is determined for each class of locomotive. The back-pressure gage supplies a permanent record of this best operating cut-off and makes it possible to reproduce it in every-day operation on the road with the assurance that maximum power when required will be immediately obtained, and that without the supply of unnecessary steam and consequent waste of fuel.

The "position of the reserve lever" has been appreciated as a very important factor in the operation, and particularly the economic operation of locomotives. The individual performance of the engine men varies widely both in the handling of the locomotive and in fuel consumption. Tests of individual performance on the Union Pacific Railroad were reported.

On analyzing the results, it was found that the individual performance of one of these enginemen when compared with the other nine as a group showed a saving in fuel per thousand gross ton-miles of 17 per cent. The tests also showed that in this group of nine enginemen there were individuals falling as much as 30 per cent below the best man. * * * * One or two enginemen were found whose performance was such that it could scarcely be improved, while one individual engineman was found using as high as 45 per cent more fuel per 1,000 gross ton-miles than was demonstrated by the test to be necessary.

Such wide variations in individual performance are not at all unusual. Of course, condition of equipment, weather, etc. must be considered, but Mr. Retterer's experiment and Fig. 1 indicate that the individual habit in the adjustment of the cut-off can and must be largely responsible for these very wide variations. The essentials necessary for good cut-off adjustment can scarcely have been appreciated in the past since many locomotives are supplied with reverse-lever quadrants with notches so coarse that it is impossible to make the fine adjustments of the cut-off which have been demonstrated to be necessary. It is evident that something better and more exact than the judgment of the enginemen is needed to indicate the best adjustment of the cut-off in order that this adjustment may be made exactly and quickly. The back-pressure gage properly used should fill this need.

The Motor Truck and L. C. L. Freight

By F. J. SCARR, Transportation Service Consulting Engineer

Transportation has advanced in economy and efficiency in proportion to the intelligent application of human ingenuity and capital investment. True advancement, however, is not in the development of any single phase to usurp in whole or in part the function to which any other phase is particularly adapted and better fitted to perform. A proper scheme of transportation demands that each means be employed in the task for which it is best suited.

President L. F. Loree of the Delaware & Hudson Company, in his address before the Holland Society last year, discussed the advancement of transportation in a unique manner. He measured such advancement by the increased productivity of the individual as outlined in the following quotation, which—with Mr. Loree's permission—has been briefed:

The first transportation undertaken by man was a personal effort in which he packed his own burdens. . . . Under this method there may be transported daily 65 pounds 15 miles for each porter, or allowing 312 days for a year's work, 152 ton-miles.

With the domestication of wild beasts, pack trains were organized. . . . A horse of average force working for eight or ten hours per day might transport on his back 200 pounds at a rate of 25 miles per day over average level country. For a year of 312 days his performance would be 780 ton-miles.

In the early eighteenth century . . . highways were built with careful attention to grades and their surfaces propertly metaled. Many cartage companies were organized and an allowance of one ton of goods for one horse was very general. With this power, 20 miles a day were covered, or for a year of 312 days, 6,240 ton-miles. . . .

There were on the payrolls of the railroads of the United States at the end of 1925, 1,753,208 employees. Making a rather arbitrary division of these employees between freight and passenger service . . . indicates that there were approximately 1,415,000 employees engaged in freight service. In the year 1925 the railroads transported 452,827,593,844 net tons one mile. Comparing the extremes only, we have 152 ton-miles per year as the paying load-carrying capacity of the porter. The railroads in 1925 transported 320,019 (paying load) per individual freight employee. That is, the productivity of the individual due to the achievements of management, as reflected in the concerted movement and in the ordered discipline; the use of capital reflected in the plant, the provision of power, and the multitudinous inventions and adaptations of machinery and tools; and his own intelligent industry, has been multiplied 2,105 times.

For the purposes of this discussion, the productivity of the individual has been calculated when using the motor truck, the latest development of land transportation. These results, together with those previously discussed, have been listed in Table 1 for convenient comparison. This is offered not as conclusive as to accurate detail, but as indicative of general relations.

TABLE 1 PRODUCTIVE ABILITY OF THE INDIVIDUAL

Means of transportation	Revenue freight per man per day	Miles transported	Ton-miles per year per man	Cost per ton-mile
Porter	65 lb.	15	152	$10.250
Pack horse (6)	1200 lb.	25	4,680	0.933
Horse and cart	1 ton	20	6,240	0.380
2-horse dray	2 tons	20	12,480	0.240
5-ton truck	5 tons	100	156,000	0.065
American railroads[1]	3.06 tons	309	295,000	0.009

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[1] 1925 actual performance; other figures are potential.

While it is recognized that the figures in Table 1 are not accurately comparable, there are certain general and interesting conclusions apparent which are adequately supported and justified.

It is interesting to note the ditsinct periods into which this table divides transportation development. These periods are clearly marked in the two columns captioned "Ton-miles per year" and "Cost per ton-mile."

In the first period neither capital nor human ingenuity have been applied to an appreciable extent, with a minimum of individual ability and maximum cost as the result.

The second period finds the application of capital in the form of muscular power and the application of human ingenuity only to the extent of animal domestication. The result, however, is to increase individual productivity thirty-fold and reduce the cost by ninety per cent.

The third period is that of additional capital use and the first application of mechanical invention in the cart and dray. The result is again to increase productivity and reduce cost.

The final period seems to be the acme of development, as Mr. Loree points out in the last sentence quoted from his address. Herein the supreme application of human ingenuity, in the development of mechanical power as well as greatly advanced auxiliary means, is made possible by the unstinted and intelligent application of capital in the form of railways and motor vehicles. This has resulted in increased individual productivity and reduced costs to a seemingly extreme degree.

It seems that the final period has been reached. Advance from the present state will be the result, principally, of refinements of established principles and practices.

The general direction of such refinements is clearly indicated by the fundamental relations of our various means of transportation. Table 1 establishes in a general way the relative merits of the various forms of land transportation.

The railroad is supreme in its "mass transportation" ability. Economic law dictates its utilization to the greatest possible extent for the movement of that class of freight for which its equipment and facilities have been designed—in general, the movement of large volume for long distance.

The porter is supreme in his individual-package movement or retail transportation ability. His capacity, short radius of action, and high cost confine his field to the narrowest of limits.

Each means of transportation bears a definite relation to the others and to the general scheme in proportion to the traffic which its relative but varying limitations particularly fit it to handle.

The Railroad and the Motor Truck

As this discussion is primarily one of the motor truck and a portion of the railroad scheme, it is necessary to examine the general relation of these two means more specifically. Therefore the data in Table 1 have been extended into further arbitrary divisions, as shown in Table 2.

Less-than-carload traffic constitutes approximately 4 per cent of the total railroad freight business and requires nearly 20 per cent of the rolling equipment for transportation. Table 2 (Parts 1 and 2) indicates that the handling of L.C.L. freight costs four times that of carload freight. This is due, primarily, to high (L.C.L.) terminal costs and low average tonnage per employee.

The potential performance of the motor truck exceeds the individual productivity of the L.C.L. freight employee. The greater cost per ton-mile, however, presents the complete usurpation of this business by the motor truck, and indicates that for much of this class of freight the railroad must remain supreme.

TABLE 2 PRODUCTIVE ABILITY OF THE INDIVIDUAL

Part	Means of transportation	Tons of revenue freight per man per day	Miles hauled	Ton-miles per man per year (312 days)	Cost per ton-mile
I	American railroads (All freight)	3.06	309	295,000	$0.009
	American railroads (C. L. freight)	3.43	309	330,700	0.008
II	American railroads (L.C.L. freight)	0.85	309 (?)	82,900	0.032
	5-ton truck[1]	5.00	100	156,000	0.065
III	5-ton truck (80 per cent load)	8.00	33	82,400	0.090
	5-ton truck (40 per cent load)	5.00	33	57,500	0.215
	American railroads (L.C.L. freight)	....	33	......	0.160
IV	5-ton truck (80 per cent load)	16.00	10	55,900	0.115
	5-ton truck (40 per cent load)	10.00	10	31,200	0.250
	American railroads (L.C.L. freight)	....	10	......	0.490

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[1] Potential figures.

High railroad terminal costs, due principally to the high platform-handling expense, cause a material change in this relation for the shorter distances.

At 33 miles, the economic point below which the average railroad cost of handling L.C.L. traffic exceeds the revenue, the relation of the railroad and the motor truck is such as to favor the latter under good motor-trucking conditions and the former for average conditions.

At this distance, on the basis of cost alone, the railroad is superior to the 40-per-cent-load-factor motor truck, while the 80-per-cent-load-factor vehicle is capable of serving at less cost than the railroad and will also reduce the time element to the minimum.

It is assumed that ten miles is the outside radius of the daily ability of the horse-drawn vehicle. The distance is well within the reach of the motor truck, which vehicle seems destined to play a middle role between the horse-drawn vehicle on the individual or retail side and the railroad on the mass or wholesale side. Dependable statistics indicated that, of the large and ever-increasing amount of traffic being handled over the highways, nearly 50 per cent is moved less than ten miles. At this distance, as indicated in Part IV of Table 2, the motor truck is eminently supreme, both in cost and expedition of movement.

Present Conditions at Variance with Economic Law

While economic law is certain to prevail, it is not as prompt of action as it is correct of judgment. Human effort to influence the functioning of this law is slow to adjustment to meet new developments. The cost of operation, while indicating the economic relation, is not a correct measure of the conditions which influence the flow of today's freight traffic. The cost to the shipper, involving arbitrarily fixed rates, and to a material extent the expedition of completing the through movement from door to door, are the chief factors affecting a choice of mode. These factors, considered in their true light, together with other related factors, present a vastly different picture of the present relation of rail and highway transportation.

No transportation is of value except as a part of the completed movement from point of origin to point of destination. That the shipper is also interested in the element of in-transit time is evidenced by changed business conditions and demands. The through movement and minimum costs, however, remain the shipper's prime interest.

In the movement of L.C.L. freight traffic the railroad performs, in general, but one portion of the completed movement. Some form of highway transportation accomplishes the collection and distribution. This condition is also true of a considerable portion of carload merchandise traffic.

The shipper is also burdened with the necessity of crating merchandise. That this item is of greater expense and weight when railroad movement is contemplated than when only highway transportation is involved, is well known.

The through movement from origin to destination involves, generally, three and four elements of expense when moved respectively by highway alone or by highway and rail. These fatcors are: Crating, Carting, Freight on Net, and Freight on Tare. These factors in combination determine the true relation of rail and highway transportation as dictated by today's conditions. Properly evaluating these elements of the completed movement indicates that the motor vehicle can successfully (and actual operations demonstrate) compete with the railroad handling of L.C.L. traffic for considerably greater ditsances than the accurate measure of economic law seems to dictate.

Today's conditions are not in accord with economic law. In spite of the human tendency to resist any change in the established order, the shortcomings of the present system will be overcome and the advantages offered by new measures will be pursued.

The motor vehicle is burdened with little terminal expense. The railroad, particularly in L.C.L. traffic, is tremendously taxed by high terminal costs—made up largely of handling expense. These characteristics are clearly demonstrated in the flat motor-vehicle and abruptly ascending L.C.L. cost curves for the shorter distances.

1. High railroad-terminal L.C.L. expense must be reduced.

2. High motor-vehicle line-haul expense must be avoided.

These principal expense factors of the two modes of transportation under consideration can be bettered materially by mutually co-ordinated effort. In the matter of terminal expense the motor vehicle is reasonably free, that item being largely absorbed by the merchant, while the railroad pays from $0.16 per net ton-mile (at 33 miles) to infinity, depending inversely upon the distance. In line-haul expense the motor vehicle is penalized a fairly constant sum of $0.065 per net ton-mile, while the railroad does not exceed $0.032.

Two conclusions result directly from the foregoing discussion:

1. To permit the utilization of railway transportation in the line haul and highway transportation in the terminal movement to the greatest possible extent demands [illegible] some efficient, economical, and rapid means of transfer from one medium to another be devised and placed in service.

2. To permit the application of a plan of mutual co-ordination between rail and highway transportation requires that present rate structures be revised to be as fully as possible in accord with the relative cost of operation of each mode.

The Unit Container

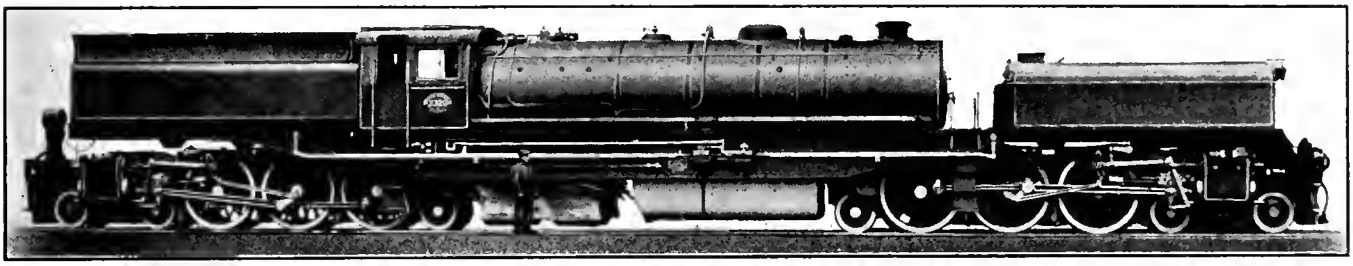
Accepting these seemingly academic but exceedingly real and practical conclusions as correct, the manner of making them effective is immediately of interest. The refinements that are necessary in advancing from our present state are simple and of proven practicability. The unit-container method of handling L.C.L. traffic will go far in the accomplishment of the above purposes.

It is not proposed to discuss here the advantages or probable method of applying the unit container to our transportation requirements. For an able discussion of this new and important phase of transportation, reference is made to a recent paper entitled, "The General Theory of Container Use," prepared by Bernard Allen, one of the author's consulting-engineering associates. Mr. Allen has also taken up the subject in a recent issue of the *Railway Age*. Here is a railroad man of many years' experience with the Canadian National Railways looking forward to the general and widespread acceptance of this specialized method of handling L.C.L. freight traffic. The unit container is not new, nor is its application to a coordinated plan of rail and highway transportation new. Such plans have been advocated and to some extent successfully utilized for a great many years; the first patents being granted on such devices in England in 1845.

The conditions, however, which make its general and widespread use certain within the near future are of reasonably recent development. The motor vehicle, with its flexibility, has not only made container interchange possible and from an economic standpoint desirable, but has brought on a demand for the type of service that its adoption will augment. The high cost of platform labor has forced the adoption of all possible labor-saving devices to keep the costs within the regulated revenue.

New business demands for lower inventories and more frequent shipment of smaller quantities with consequent shortened warehouse clearings have created conditions particularly appropriate to usher in this new development.

As other special classes of traffic have been served by special equipment and facilities, so L.C.L. traffic—the most expensive division of the railroad business—will gradually be accorded the same treatment, with correspondingly favorable results in increased efficiency and economy. The present stage of transportation development will by this means have advanced through additional refinement, with advantage to individual productivity, cost, and the shipping public.



Garratt-Union Type Locomotive for the South African Railways—Built by I. A. Maffei, A.—G., Munich.

The Heaviest Locomotive, Built in Europe

The well-known Locomotive Works, I. A. Maffei A.-G. Munich, have turned out during the last few months some articulated locomotives of the Garratt-Union type, ordered by the South African Railway Administration.

Remarkable for design and size, these engines were constructed under supervision of the South African Railway Engineers. Messrs. Maffei hold patents, which cover some principal details of the design.

These giant locomotives were ordered for the express service between Cape Town and Pietermaritzburg, a stretch of the South African railway system well known for the long stiff gradients and the numerous narrow curves thereon.

The 24-wheeled engines weigh 186 tons in working order, are 85 feet long overall, and with the tractive power of 44,000 lbs. at the draw-bar are the heaviest locomotives so far built in Europe.

The three pairs of coupled wheels at each end of the locomotive are driven by twin-cylinder steam engines in the usual way. The control of the valve gear is effected by a steam driven reversing gear. The handling of this enormous engine has been facilitated in other ways too. The grate of 59.5 square feet is not stoked by hand, but a Duplex mechanical stoker brings the coal from the bunker and spreads it correctly over the grate. The fireman's work is considerably reduced, for he has only to look after this auxiliary engine and has therefore more time to watch the signals of the line.

Messrs. I. A. Maffei A.-G. have completed last Spring ten engines of the same type, but of somewhat lighter design, weighing 165 tons in working order, also fitted with "Duplex" mechanical stokers.

It is a remarkable fact that Messrs. I. A. Maffei A.-G. have built for the third time, what was then the heaviest locomotive of Europe; the first record locomotive was the 12-wheeled Mallet engine for the Gotthard Railway, Switzerland, built in 1890, weighing 86 tons, the second the 16-wheeled Mallet locomotive of the Bavarian State Railways, built in 1913 and weighing 126.6 tons.

Details of the 2-C-1 + 1-C-2 (4-6-2 + 2-6-4) Articulated Garratt-Union Type Locomotive for the South African Railways, Built by J. A. Maffei A-G, Munich

Working pressure	180 lbs. per sq. ft.
Diameter of cylinders	19½ in.
Length of stroke	26 in.
Diameter of driving wheels	5 ft.
Diameter of carrying wheels	2 ft. 6 in.
Average tractive power	44.500 lbs.
Heating surface of firebox	241.29 sq. ft.
Heating surface of tubes	2,156.69 sq. ft.
Superheater heating surface	824.0 sq. ft.
Total heating surface in contact with fire	3,221.98 sq. ft.
Grate area	59.5 sq. ft.
Weight empty	135.5 tons
Adhesion weight	110.3 tons
Weight in working order	184.5 tons
Rigid wheel base	129 in.
Total wheel base	76 ft. 7 in.
Gauge	3 ft. 6 in.
Smallest radius of curves	300 ft.
Overall length of locomotive	85 ft. 0 in.
Overall height of locomotive	12 ft. 11 7/16 in.
Overall width of locomotive	9 ft. 11¼ in.
Capacity of water tanks	6,000 gals.
Capacity of coal bunker	13.5 tons
Distance between pivot centres	39 ft. 6½ in.

Railway and Locomotive Engineering

A Practical Journal of Motive Power,
Rolling Stock and Appliances

Published Monthly by
ANGUS SINCLAIR COMPANY
136 Liberty Street, New York
Chicago Office: 168 North Michigan Avenue
Telephone Rector 0746. Cable Address "Locong." N. Y.

Harry A. Kenney, Prest. and Man. Ed. J. Snowden Bell, Associate Editor
W. E. Symons, Associate Editor Thomas P. Kenney, Secretary

LONDON REPRESENTATIVE
The Locomotive Publishing Company, Ltd., 3 Amen Corner, Paternoster Row, London, E. C., England.

SUBSCRIPTION PRICE

$2.00 *per year,* $1.00 *for six months, postage paid in the United States, Canada and Mexico. For other parts of the world,* $2.50. *Single copies,* 20 *cents. Remit by Express Money Order, Draft, Post Office Order or Registered Letter.*

Mailing address can be changed as often as necessary—always give old and new address, and if you subscribe in a club, state the name of the agent.

Please give prompt notice when your paper fails to reach you regularly.

Entered as second-class matter January 15, 1902, at the post office at New York, New York, under the Act of March 3, 1879.

Back Pressure on Locomotive Pistons

At the annual meeting of the American Society of Mechanical Engineers, Mr. Thomas C. McBride presented a highly interesting paper on the subject of Back Pressure on Locomotive Pistons which is published elsewhere in this issue. Its presentation developed considerable discussion by the members present, in which features of the design of locomotive boilers, the proper ratio between grate area and exhaust blast, back pressure gauges, etc., was touched upon. However, like the paper itself the whole of it was directed to features of design, or means to minimize back pressure on pistons, but none of which struck at the real root of the trouble.

Back pressure gauges and pyrometers in the cab serve a good purpose in the rather refined development of our modern locomotives, but why in name of common sense put off the day when solution of the problem must be met. It is well known to all those well versed in regard to locomotive operation that a back pressure gauge is neither a remedy or cure of the trouble. It only records something as a condition that is already known, the prevention or cure for which should first be vigorously applied, after which these other refinements might well be employed.

It is safe to say that in the past 25 years, unnecessary back pressure on pistons has cost the railways $750,000,000 in fuel wasted and an additional $250,000,000 due to lowered engine efficiency. In other words it has cost a billion dollars. Assuming the possible saving at only 5 per cent on the fuel bill of 1926 which was $418,503,588, it would amount to $20,725,179. If the potential earning power of locomotives were increased in the same ratio, the saving plus the money value of increased engine efficiency would be about $6,908,393, or a total of about $27,633,572.

From the folowing tabulation one can see at a glance the cost of coal per ton at the mines, the total cost of fuel and its relation to operating expenses, the tons of freight handled and the average tons per train during the 25 year period.

Year	Cost of Locomotive Fuel	Proportion to Operating Expenses	Tons Freight Carried	Average Tons in Train	Cost of Coal at Mines Per Ton
1926	$418,503,588	8.79	2,549,000	721	$2.21
1925	417,552,715	9.04	2,390,000	693	2.10
1924	448,636,810	9.74	2,260,000	667	2.14
1923	542,305,784	10.87	2,411,000	662	2.68
1922	530,338,602	11.77	1,908,000	630	3.02
1921	535,305,769	11.49	1,741,000	596	2.89
1920	689,632,039	11.58	2,305,000	668	3.22
1919	485,574,445	10.89	2,121,000	675	2.47
1918	512,786,938	12.64	2,402,000	656	2.56
1917	401,297,302	13.92	2,362,000	620	2.07
1916	257,371,124	10.49	2,283,000	553	1.24
1915	216,895,203	10.38	1,802,000	474	1.13
1914	242,800,799	11.03	1,976,000	452	1.17
1913	249,507,624	11.49	2.058,000	445	1.18
1912	234,246,470	11.87	1,845,000	407	1.15
1911	231,693,773	12.09	1,782,000	383	1,11
1910	217,780,953	11.95	1,850,000	380	1.12
1909	188,735,868	11.80	1,557,000	363	1.07
1908	201,905,054	12.09	1,533,000	352	1.12
1907	200,261,975	11.47	1,796,000	357	1.14
1906	170,499,133	11.11	1,631,000	344	1.11
1905	156,429.245	11.27	1,423,000	322	1.06
1904	158,948,886	12.12	1,310,000	308	1.10
1903	146.509,131	11.67	1,304,000	311	1.24
1902	120,074,192	10.77	1,200,000	296	1,12
Totals	$7,985,603,422	....	46,899,000	...	...
Increase	248%	....	112%	143%	93%

It will be noted that the cost of fuel at the mines has advanced 93 per cent, the tonnage moved has increased 112 per cent, and the average train load 143 per cent. Yet, the total fuel bill has advanced 243 per cent.

It must not be overlooked, however, that while the tonnage moved in 1926 was much greater than in 1923, the total fuel bill was about $123,000,000 less. This reduction in operating expense was brought about through the lower price of fuel and the pronounced economies effected in its use.

Great as that economy appears, virtually none of it was due to reduction of unnecessary back pressure on pistons, "the arch enemy of locomotive economy." This highly inviting field for increased economy has been for some unknown reason sadly neglected. Those who preach economy and higher refinement in the design of locomotives, shun it as they would a pest house.

We have and are still devoting much time, energy and expense to improve and perfect devices that have to do with the conversion of water into steam and for getting the steam from the boiler to the cylinders, but have fallen down quite badly in getting the steam out of the cylinders in as economical a manner.

It might be said that in most cases the exhaust steam is simply permitted to flow out through exhaust passages, nozzle and stack, to the atmosphere with little regard to the amount of back pressure or its retarding effect on the pistons which detracts from the engine's real pulling power and in overcoming which a great loss in fuel is involved.

If an engineer were known to run with brakes slightly stuck he would be called sharply to account and very properly so, but thousands of them run engines every day with unnecessary excessive back pressure on the pistons which is equivalent to slightly stuck brakes, and they are absolutely powerless to furnish any measure of relief although the same could be easily provided and at the same time the direct and indirect saving effected would run into many millions of dollars.

The average cost of fuel for all locomotives per annum is in excess of $9,000, while some engines use twice that amount, yet there are thousands of engines fully equipped with modern devices for effecting economy in various ways, that yield a very slight return on these investments and a much below par service from the complete unit for the simple reason the *"machine is choked up and can't run as it should."*

It is not surprising that railway officers exercise caution in accepting the numerous propositions with which they are beset by the wonderful assortment of railway doctors that have sprung up in the last two decades. Many of their schemes are too visionary to be considered seriously, but may in a measure account for some very important matters, badly in need of attention, being deferred from time to time or overlooked entirely. This should not be the case, however, for an executive or the head of a department should know personally the state of affairs in all matters consigned to his keeping and should correct errors, make necessary improvements, or if need be, clean house without the aid of outside talent.

Railway officers are all very busy men, some are so badly behind with ever increasing current affairs that of the multiplicity of things for which they are responsible some are neglected, and there is no single feature of locomotive design or operation, having as great an influence or effect on the efficiency of the machine as a transportation unit, that has been as badly neglected as the exhaust nozzle and its related parts, which have to do with back pressure on pistons.

Much has been written and said on this subject of back pressure on pistons, and while many were wholly theoretical as to conditions and means of improvement, little or no constructive work has been accomplished. The fire box or front end of a locomotive is a poor place to locate or attempt to operate any kind of mechanism affected by high temperatures, for in the former it will. burn out and in the latter it will suffer from heat, abrasion, and gum up, so that from one or all of these causes failure too often results.

Variable exhaust nozzles, or at least most of them, belong in this latter class and the writer fully concurs in the views of those who seek to *escape the curse* that some of these *contraptions* would surely bring upon any one who stood for them. On the other hand the writer does not believe in running an engine, day, week, month and year in and out with excessive back pressure on pistons, thus wasting thousands of dollars in fuel and actually preventing the engine from doing the work it could do if simply given relief and an opportunity. As a rule medicine don't taste good, and is expensive, but as between dragging one's self around always below par, when a very practical inexpensive remedy is available that will remove your trouble, restore your vigor and increase your capacity and efficiency, the practical man will say, "Give me the medicine."

There are many thousands of locomotives running in the United States with back pressure on pistons which in wasted fuel and decreased capacity combined will in the aggregate amount to many millions of dollars, and if means were provided for nozzle adjustment to suit conditions of service, a large part of this waste could be saved. Until some effective device or methods are actually applied and the results recorded, it cannot be said that conservation of fuel has received or is receiving the attention it deserves.

Millions of dollars are now being wasted in fuel on account of excessive back pressure on pistons that could be relieved by the use of some means of controlling the exhaust steam at nozzle tip, and to this sum may be added an equal number of millions on account of the loss of efficiency of the engines and increased cost of maintenance.

The hundreds of millions of capital in locomotives, should, as the result of increased mileage and hours of service actually producing revenue ton miles and passenger miles, bring greater return to their owners on investments, and effect a wonderful saving in overhead or stand-by losses. The efficiency of a large percentage of the entire schedule of steam locomotive may be materially improved by elimination of excessive back pressure on pistons.

Railway and Locomotive Engineering has always stood for higher development and greater economy in locomotive practice and particularly in the item of fuel. From the pen of one of its staff during the past five years there has appeared in its pages number of articles on this subject of back pressure. We have at no time theorized on the subject. What has been written is based on personal knowledge of thirty years experience in the design, maintenance and operation of locomotives.

We may intrude the suggestion, that if they will refer to the February 1924 issue of this paper, or study pages 70 to 159 of the Proceedings of the Traveling Engineer's Association for the year of 1924, they will find the disease pretty clearly diagnosed, and simple, inexpensive, practical remedies prescribed.

The Motor Truck and Motor Bus

Elsewhere in this issue there is published a paper by Mr. F. J. Scarr entitled the Motor Truck and L. C. L. Freight which he read at the annual meeting of the A. S. M. E. The author brings out many good points favoring the use of motor trucks as auxiliaries to railway transportation, but quotes from Mr. L. F. Loree, president of the Delaware & Hudson, who has given the subject much thought and study.

In a discussion of the paper, it was brought out that some railways had a false impression as to the effect of motor trucks or motor busses on their revenues. One speaker pointed out that the passenger agent of a certain carrier had complained that busses had cut into their passenger revenues to an amount of more than a million dollars in a single year, but that passenger agent failed to mention that the freight revenues of the line with which he was connected had increased something like thirty million that same year. Any railway company that would not gladly trade one million dollars of passenger revenue for thirty million and great deal less of freight earnings is badly in need of overhauling.

The suitability and great value of the motor truck in expediting the movement of certain kinds of freight under conditions to which steam railway facilities do not lend themselves has been established.

Efficiency

One of the most common expressions heard among engineers concerning their engines is the word "efficiency" yet there is considerable uncertainty concerning the real meaning of the expression as employed in engineering. The term in mechanical science has become technical, and restricted to a definite mechanical expression in the form of a ratio. When thus used its meaning is well understood, but its importance is increased by giving it a broader definition and a wider range of application. Efficiency is a result compared with the effort expended.

Beginning with the familiar one of the steam engine, one may have the following efficiencies. If 10 per cent of the energy of the steam admitted into an engine be transmitted into work, then with the efficiency of steam compared with the energy in it when admitted to the engine will be one-tenth or 10 per cent. If 5 per cent of the energy of the steam in the boiler be lost by radiation, leaks, friction, etc., in passing from the boiler to the cylinders of the engine, then will the efficiency of the steam, compared with its energy in the boiler, be 0.10x.95 or 9½ per cent. If the efficiency of the boiler be 0.70, that is, if the boiler utilizes 70 per cent of the theoretical heat of the fuel, then will the efficiency of the system referred to be

0.95 x .0705 or more than 7 per cent. If the fuel be coal, and the heat in it be one fourth that in the plants from where it was produced, then would the efficiency of the system, compared with the heat in the plants from which coal was produced, be 0.017625. If the heat energy in the plants be one per cent of the energy received from the sun, then would the energy of the system referred to the original source of energy be 0.0017625 or less than one-fifth of one per cent.

The efficiencies here given are less than unity, and it is always less than unity when the result is obtained from the source without an intermediate agency, deriving more or less power from another source. When the latter condition is involved the efficiency may exceed unity. For instance, if money be carried, or deported with another without being used, its efficiency could not exceed unity, and although practically the efficiency may be unity, yet considering friction wear and tear, and accidental losses, it is liable to be less than unity. If however, the money be loaned, and the borrower uses it in trade, commerce or agriculture he may be able to pay for the use of it, or if he pay 6 per cent, periodically, the efficiency of the lender will be 106 per cent. If the borrower expended the money in raising a crop of wheat, and received five times as much money for it as he expended, the efficiency would be 5 or 500 per cent. In this case the soil and other elements of nature constituted an intermediate agency which contributed to the results independently of the labor expended in labor, seed, etc. If, however, the crop be referred to the wheat producing capacity of the soil—that is, if the chemical elements of the wheat be compared with the corresponding chemical elements in the soil—the efficiency would be less than unity and might only be a small fraction thereof.

Radio Communication on Trains

After many months of developmental work on the lines of the New York Central, the radio engineers of the General Electric Company have designed an effective and reliable system of radio communication between the front and rear ends of trains, particularly long freight trains.

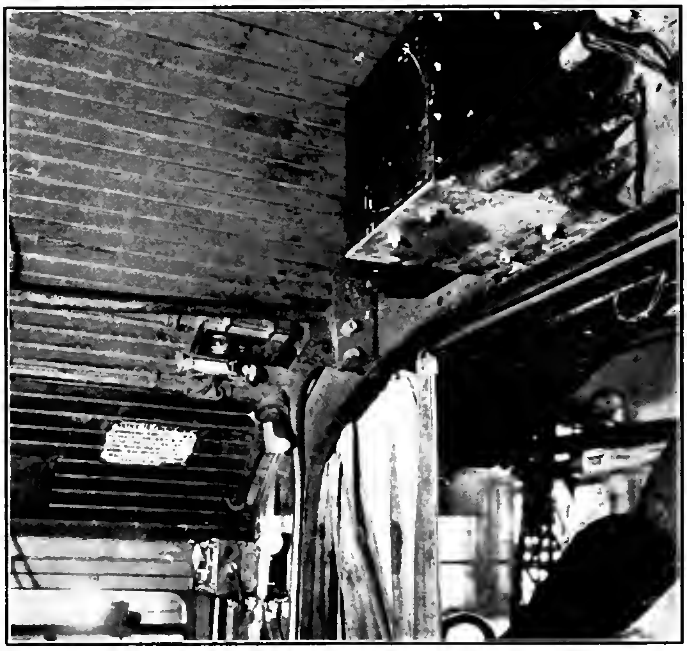
The new system and some of the problems encountered were explained recently by I. F. Byrnes, a radio engineer, at a meeting of the New York Railroad Club.

Preliminary investigation was carried on at Schenectady on engine and caboose. Several different types of antenna were investigated on the locomotive and it was found that the most effective type consisted of a wire running parallel to the boiler and about fifteen inches from it. This was stretched between the stack and the rear end of the cab roof, as far as possible from the boiler and at the same time within the clearance limit of the right-of-way. The caboose antenna was placed four and a half feet above the roof, running parallel to the caboose. Antennas of the type used on engine and caboose do not possess any marked directional characteristic, but they are inefficient radiators, due to their low effective heights, and for this reason require more power for a given transmission range than would be necessary if higher antennas were available.

Tests showed that the 2300 to 2750 kilocycle band offered the best transmission frequency. In order to provide a strong telephone signal at a distance of from one to two miles a power of 50 watts delivered to the antenna was found necessary. While communication is possible on less power, there must be sufficient margin to care for unusual conditions.

A radio telephone system must incorporate an effective calling system if it is to have a maximum degree of utility. The original work included the use of a bell actuated by a relay for calling purposes. This arrangement was later discarded because it was comparatively easy to secure false indications of calls. Excessive jars caused relay contacts and it was also possible for static and other disturbances to cause the bell to ring. The calling system finally developed, utilized a loud speaker which produces a shrill note whenever a push button is depressed at the transmitting end. The pitch of this note is adjusted so that it is easily heard above the usual train noises. In addition the loud speaker may be used in place of earphones for receiving conversation when the running noises are not too great.

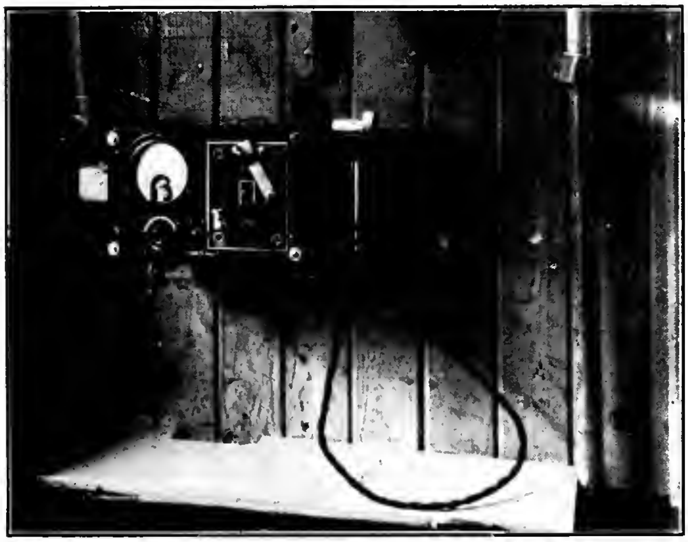
Radio telephone equipment is classified as either simplex or duplex. The simplex system requires that a small button or similar device be depressed when one wishes to talk and upon releasing the button the apparatus is automatically transferred to the receiving condition. With a duplex installation, full automatic telephony may be carried on similar to that with an ordinary telephone. In order to secure the latter condition, considerable complication is introduced into the equipment and, in addition, the radio transmitter must operate while receiving is taking place.



Microphone and Control Unit at Left, and Above Loud Speaker Installed in Cab of Locomotive

After a number of comparative tests were carried out it was agreed that the advantages of simplex operation out-weighed the additional convenience of a duplex installation. The simplex sets require less power, will not set up as much interference as the duplex, and more simplex installations can be operated within a given frequency band than those of the duplex type.

A great many tests were made with the preliminary equipment along the Mohawk Division of the New York Central Railroad. Very successful telephone communication was carried out and many instances were recorded where great assistance was rendered because such communication was available. Much interesting data was secured with regard to transmission phenomena. Fading, such as commonly occurs in broadcasting or wherever transmission over considerable distances is attempted, does not take place with the train sets. Communication is, however, interrupted or reduced in volume, by the presence of steel bridges or signal towers along the right-of-way. While the effect of such structures on the received signal is equivalent to fading, it might more properly be classified as shielding or absorption effect. When the locomotive antenna is directly beneath a steel signal tower there is likely to be a marked reduction in the strength of the received signal at the caboose. If transmission takes place from the caboose under these conditions it is still more difficult to receive in the locomotive. As long as the locomotive or caboose antennas are not directly beneath a steel structure, no apparent reduction in signal is obtained. Curves along the right-of-way do not have any apparent effect on the transmission, nor do passing trains seem to exert any interfering influence.


Microphone and Control Unit in Caboose

After operating the first set for a period of months, under actual running conditions mechanical weaknesses in the first set were worked out and several improvements made in the circuit and in the calling system.

The metal box enclosing the transmitter and receiver is made of steel boiler plate, welded together, and is intended for installation on the deck of the tender. It is completely weather tight, being made to exclude water or other foreign material. The equipment is built for simplex operation only, and a relay is provided on the front panel for interchanging the circuit from transmission to reception and vice versa. The entire assembly is supported by eight springs, and in addition a system of snubbers is provided to prevent excessive oscillation.

The transmitter compartment contains three of the 50 watt size tubes and one of the 7½ watt tubes. Four of the latter size tubes are used in the receiver. The 7½ watt tubes are the standard train control type which are already in use on many railroads. The 50-watt tube is known as type UV-211 and is a standard design used for aircraft and marine applications for a number of years.

The power unit for the equipment, which contains the necessary dynamometers, filter condenser, reactors, etc., is housed in a metal container. Two dynamotors or two-bearing motor generator sets are utilized. The larger one only operates when transmission is taking place and supplies plate voltage at 1,000 volts d.c. to the transmitter. The smaller machine runs at all times when the equipment is on the road and delivers plate voltage and bias voltage for the radio receiver. The use of this smaller machine permits the elimination of all batteries.

An especially strong type of loudspeaker, capable of producing a maximum amount of volume, was developed for the set. This loud speaker may be bolted to any convenient metal support inside the locomotive or it may be fastened to a bracket anywhere in the caboose. The opening for the sound is protected by means of a heavy wire screen so that an accidental blow will not damage the sound producing unit inside. Excellent speech quality may also be obtained from this loudspeaker obviating the use of a head-set under average conditions.

In adapting the new equipment for train installation it was found advisable to mount the antenna on the tender instead of along the locomotive boiler. The antenna consists of a brass pipe mounted about twelve inches above the tender tank. The antenna is low enough so that it does not interfere with taking water or with coaling operations.

The total amount of power drawn by the equipment when transmitting is approximately 30 amperes at 32 volts d.c., while in receiving, the current drawn from the 32-volt battery is approximately 5 amperes. This is the current required by the receiver dynamotor and the receiver filament.

A second application of radio other than front to rear end communication is an installation for hump or classification yard service. A radio telephone transmitter similar to the first type has been installed at the Selkirk yard of the New York Central. The hump locomotive is equipped with a radio receiver and a loud speaker and receives voice signals and instructions from the yardmaster at transmitting end. This apparatus has been in service for several months and is giving very satisfactory results, particularly in stormy or foggy weather when the older methods of signaling are difficult to carry out.

An Improved Flue Cleaner

An improved locomotive boiler flue-cleaning machine in service at the shops of the Detroit, Toledo & Ironton, has greatly reduced the time needed to free this equipment of scale.

Two hundred scale-incrusted flues may be thoroughly cleaned within two to three hours by means of a tumbling device and water. The attention of two men is required for approximately one and a half hours to load and unload that drum. Otherwise the preparation of the flues for renewed service is purely mechanical.

Under former methods flues were cleaned one at a time. Often repeated passes through a boring device were necessary to remove the scale. Two workmen required two days to clean a set of locomotive boiler flues.

The new flue cleaner is 222 inches in length and 42 inches in diameter. It is made of one-inch steel, heavily reinforced, with a one-inch steel liner, and is mounted between pedestals. An electric motor revolves the drum at a speed of 60 revolutions a minute. A door 25 by 216 inches admits the load of flues to be cleaned.

Small pipes admit a fine spray of water. As the cleaner revolves with its load of flues tumbling about, the incrustation loosen, crumble, mix with the water, and fall out through perforations into a concrete pit below.

The water and scale together act as a grinding compound, cleaning the flues. A catch-basin and drain disposes of the water and sediment in the pit.

No dust is encountered in the operation of the machine, and any weakened flues in the set are fractured so that they can be recognized.

The Importance of Locomotive Assignment*

Requirements of Each Division Should Be Considered in Assigning Locomotives

By H. J. TITUS, Franklin Railway Supply Company

For convenience of study, operating expense may be classified under the four general headings of maintenance of way and structures, maintenance of equipment, transportation and general. From an analysis of the various items of expenditure, it is found that the tendency of certain items is to remain constant, regardless of the volume of business handled, while other items show a wide fluctuation with the business. From a study of the Interstate Commerce Commission statement of railroad expenses for 1925, it is found that of the total operating expenses, 17.8 per cent for the maintenance of equipment, 50.5 per cent for conducting transportation, and 4 per cent for the general expense.

Further analysis shows that during the period from 1916 to 1925 the relationship of the transportation expense to the total expense shows a decreasing tendency, whereas the other items show an increasing tendency. Knowing that certain items of the operating expense are constant, whereas others are variable, the expenses for the 1925 operation were approximated and divided between these two classes of expenditure. The total maintenance of way expense comprises 17.8 per cent of the total operating expense. Of this amount 39 per cent is variable, whereas 61 per cent is a constant expenditure. The maintenance of equipment expense, amounting to 27.7 per cent of the total operating expense shows that 79 per cent of this expenditure is of a variable nature, and 21 per cent constant. The expenditure involved in conducting transportation amounts to 50.5 per cent of the total operating expense, with 67 per cent of a variable nature, and 33 per cent constant. The general expense, amounting to 4 per cent of the total expenditure, is of a constant nature. From these data it will be observed that approximate division of the operating expense. From an inspection of the various items making up the constant expense, such as superintendence, taxes, insurance, despatching trains, interlocking plants and crossing protection, it is found that the constant expense items do not present a very fertile field for economy. The best promise of economy lies with the variable expenditures. Of the various items it is found that the item of transportation, having 67 per cent of the expense of a variable nature, offers the most promising opportunity for economy, while the maintenance of equipment expense, having 79 per cent of the expense of a variable nature, is second in importance.

Considering first the transportation expense, it is found that the direct expense of conducting transportation, which is of a variable nature, and includes wages, fuel, water, lubricants, train and locomotive supplies, and enginehouse expense, for yard and road service in 1925, constituted approximately 60 per cent of the total transportation costs, and 89 per cent of the variable cost. While the figures given are representative of the 1925 performance, it is found that during the ten year period, from 1916 to 1925, approximately the same relationship existed. For road service alone, these direct expenses of transportation amount to approximately 45 per cent of the total expense of transportation, and 67 per cent of the variable expense as related to transportation. Therefore, for introducing economy in the transportation expense it appears that the direct expenditures for road service should receive first consideration with the yard service direct expense of secondary importance.

Thus, in order to obtain the most economical operation, it becomes necessary to study seriously the various elements of operation which affect the direct transportation costs as a whole, or the principal elements thereof. There are, of course, several elements, such as power of locomotives, length of division, length and percentage of ruling grade, curvature, location and extent of facilities such as water tanks and sidings, the class of business handled and the flow of tonnage through terminals, which must be taken into consideration.

After investigating all of the items which affect an economic operation, it will be found that the study points to power as the most important item.

From a glance at the variable transportation expense, it will be observed that all of the direct expense items, except fuel, are practically constant for each train unit, regardless of size and weight. Fuel will depend, to a great extent, on the train load. Therefore, to obtain the greatest economy per ton-mile handled, it becomes necessary to consider increasing train loads, thus decreasing the number of train units and train miles to do a given amount of work. This may be accomplished in either one or two ways, or a combination thereof. Maximum grades may be reduced, thus permitting heavier train loadings, or the power of the locomotive may be increased, thereby producing the same results. In any event, it becomes a necessity to consider the type and power of the locomotive to be assigned to a particular division, so as to obtain the maximum results. Also from an analysis of the direct expense, it will be observed that the items of fuel and enginehouse expense make up a large percentage of the total direct expense. Therefore, in considering the type of power it becomes necessary also to consider the various fuel and labor saving devices which may be applied to a locomotive.

In 1925 the majority of the maintenance of equipment expense was divided between the items of maintenance of locomotives, freight cars and passenger cars. Of the total expenditures for maintenance of equipment 36.5 per cent was for locomotives, 29.5 per cent for freight cars and 7 per cent for passenger cars. During the past three years, there was only one year in which the maintenance expenditures for freight cars exceeded that for locomotives. The expenditures for locomotive maintenance varied from 32 per cent to 40 per cent of the total maintenance of equipment expenditures over the period of the last ten years, while freight car maintenance has varied from 29 per cent to 37 per cent of the total expenditure for maintenance during the same period. The tendency of the percentage relationship of these items of maintenance expenditures have been downward during the past three years, the percentage of the total expenditures obtained in 1925 being nearly equivalent to that obtained in 1916 in the case of locomotive maintenance, and less than that obtained during the same period in the case of car maintenance. Thus, with a decreasing ratio of maintenance of equipment expense to the total operating expenditures, and a decreasing tendency in the ratio of the principal items to the total of the maintenance of equipment expense, it is obvious that marked economies in these expenditures are being effected.

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* *A Paper Read Before the Central Railway Club.*

In general, the tendency to increase the unit power of the locomotive, thereby making it possible to handle a greater volume of business with a less number of locomotive miles, naturally reflects itself in a reduction in the maintenance expenditures for locomotives. Individually, the maintenance expenditures for locomotives will depend on the class of service to which they are assigned, the physical characteristics of the road and the number and size of drivers required for the same power output. These items all influence the maintenance cost of locomotives.

In one instance, with several designs of locomotives operating in the same class of service over the same territory, it would be found in taking average maintenance expenditures for a number of each class, that there was a wide variation in these maintenance costs. The locomotives, while of different designs, were of approximately the same age; therefore, the variation in maintenance expenditures for the different classes of locomotives were not because of age, class of service or physical characteristics of the road, as all of these were constant, but did vary because of the locomotive design. The design was feed water heaters and stokers, but the Mikado class was equipped with a booster and, therefore, due allowance should be made for the booster maintenance. The results showed that for a number of locomotives of each class the average maintenance cost per locomotive mile did vary with the design as follows:

Mallet type	52 cents per locomotive mile
2-10-2	48 cents per locomotive mile
Light Mikado type with booster	27 cents per locomotive mile

In another instance sufficient data as to the maintenance expenditures were available for a number of two classes of locomotives. In this case the locomotives, being of practically the same age, were operated in a similar class of service over the same territory, although these locomotives were actually designed for different classes of service. Also in this case all the elements effecting locomotive maintenance were constant, except the element of design. One locomotive was of the Pacific type, while the other was of the Consolidation type. The average maintenance cost for a number of the Consolidation type locomotives was $.30 per locomotive mile, whereas for several Pacific type locomotives it was $.19 per locomotive mile.

Factors Affecting Power Assignments

Because of the variation in locomotive maintenance costs with the type of locomotive, the assignment of locomotives to a particular division or class of service becomes a very vital subject, not only from a transportation expense item, but also from a maintenance of equipment point of view. Thus, before an assignment is made, a thorough study should be made as to the economic value of a particular type of locomotive for the work necessary. An analysis of this character should apply to all classes of service, such as through freight, local freight, branch line, passenger and yard service. Each class of service is a problem in itself, and it will be seldom found that a locomotive which produces economy in one service will exactly meet the requirements of another class of service.

In the assignment of power to a territory, for the purpose of handling freight trains, there are several important items which must be considered. Of primary importance is the item of traffic. Is the traffic in sufficient volume so that full tonnage trains may be handled with the class of power which is in use at the present time? With a more powerful locomotive, would it be possible to obtain the same relationship between the actual tonnage handled and the rated tonnage?

In other words, is there a sufficient tonnage available at the terminals at all times, so that it will not be necessary to run partially loaded trains? Of secondary importance comes the physical characteristics of a division. Are they such that maximum train loads may be handled with due despatch? Are the maximum grades of great length, or are they short so that they may be considered as velocity grades? Are the physical characteristics such that the maximum gross ton miles per train hour can be produced at the present time with the existing power, and can this rate of production be improved with a more powerful locomotive? With conditions, which justify retaining the same power per unit, would it not be possible to obtain a more economic operation with a locomotive of different design, with supplemental power, produced through the use of the locomotive booster? On the other hand, if an increase in the power per unit is justifiable from the economic standpoint, should this increase in power be provided with new locomotives through the medium of increasing the number of drivers, or weight on drivers with a consequent increase in the total weight of the power unit and cost thereof, or should it be obtained with the existing locomotive and the locomotive booster? This is especially pertinent in view of the fact that the capital expenditure involved will be at least six or eight times greater in the case of new power. These are some of the questions which must receive consideration in procuring and assigning power to produce the most economical operation.

On one road data relative to individual locomotive maintenance expenditures have been obtained for several years. Recently these data proved to be very valuable in determining the costs of operation for one class of service, and were used in determining the economic advantages that could be realized from this service by employing a different design of locomotive. The service referred to was of the preferred class and, consequently, demanded high speeds. Originally this service was handled with a Pacific type locomotive which had ample power adequately to handle the business offered, as it came from the connecting lines. As time went on, this business was gradually expanded until the trains delivered by the connecting lines could no longer be handled in one train unit with the Pacific type locomotive. If it were desirable to continue using Pacific type locomotives in this service, the trains as delivered would of necessity either be divided into two trains, or else doubleheaded. In either event, the cost of the operation would be increased. Therefore, it was decided to employ a locomotive of different design, which had ample power to handle in one train unit the business as it came from the connecting lines. This move naturally lowered the unit cost as a whole, because of the larger tonnage per train unit. After these locomotives had been operating in this class of service for a considerable period of time, an analysis and comparison was made of the average maintenance costs of the locomotive used in this service.

From this investigation it was found that instead of obtaining an average maintenance cost of $.19 per locomotive mile, as was obtained with the Pacific type locomotive, the maintenance cost had increased to $.30 a mile for the same operation when the Consolidation type locomotive was used. This represented an increase of 58 per cent in the maintenance locomotive cost for the same service rendered.

Discovery of this fact led to a study of local conditions, to determine whether or not a successful operation could be obtained with the Pacific type locomotive equipped with the locomotive booster, it being believed that economy from operation could be obtained. The result of the investigation showed that the Pacific type locomotive equipped with the booster would develop the same starting capacity as the Consolidation type locomotive, with a slight deficiency in power at eight miles per hour.

At a speed of 25 m. p. h., or greater, the Pacific type engine proved to be the better engine. The conditions which govern the loading of these engines are that the engine must start the train on the ruling grade, and that schedules must be maintained. These conditions could be adequately met with the Pacific type engine equipped with the booster.

Booster Adds to Maintenance Costs

The application of a booster will, of course, increase the maintenance costs to a slight extent because of the necessity of maintaining additional equipment. This cost for maintaining the booster, which furnishes 25 per cent of the total power of the locomotive and booster, only amounts to one-half cent per locomotive mile, which is almost negligible in comparison with the locomotive maintenance cost, being merely 2.6 per cent of the cost for maintaining the Pacific type locomotive. Thus, the saving realized in this case with the same work performed is the difference between $.30 a locomotive mile for maintaining a Consolidation type locomotive, and $.195 a locomotive mile for the booster equipped Pacific type, giving a saving of $.105 per locomotive mile in favor of the operation with a Pacific type locomotive equipped with the booster. Was this a worthwhile saving in view of the fact that this one service required over 400,000 locomotive miles annually?

On another road the volume of business had steadily been increasing to such an extent on one subdivision, that greater tonnage per train was brought into the terminal than could be handled over the particular subdivision with the power at their disposal. Therefore, it was necessary to operate more train units than was formerly the case. The officers realized that a more powerful locomotive unit would make it possible to reduce the train units and, consequently, the train miles, and thus re-establish the balance between the subdivisions. In addition, greater unit power would make it possible to decrease the unit costs of operation. It developed that consideration was given to a 2-10-2 type locomotive, or the equipping of their existing Mikado type locomotives with the locomotive booster.

With the 2-10-2 type locomotive which was considered, it would have been possible to increase the train load by approximately 500 tons, whereas with the Mikado type equipped with the booster the train load would be increased by 400 tons. Offhand, it would appear that the 2-10-2 type locomotive would prove to be the more economical of the two because of the greater load which could be handled. This road, however, made a very thorough analysis of the situation to determine which method of obtaining the greater unit power would prove the more beneficial. Careful estimates involving the principal items of direct expense, including maintenance, fuel and wages, and enginehouse expense, were made for the operation, both with a 2-10-2 type locomotive and the Mikado type with a booster. It was believed that the train and locomotive supplies would be approximately the same in both cases. It was found from these estimates that, whereas the existing operation was costing 73.4 cents per thousand gross ton-miles for the direct transportation expense and locomotive repairs, the estimated operation with the Santa Fe type locomotive would cost 64.2 cents per thousand gross ton-miles, and the operation with the existing power equipped with the locomotive booster would cost 61.1 cents per thousand gross ton-miles. In other words, the maintenance cost of the 2-10-2 type locomotive offset, to a certain extent, the savings that could be realized from greater train loading. The road naturally chose the operation giving the least costs. Ten locomotives were equipped with the locomotive booster and placed on the subdivision, where twelve locomotives were necessary previously, so that a thorough test might be made to determine the economic advantages. The operation with these engines was closely watched, but no statistical data was obtained until these engines had been in operation for a considerable period of time, it being believed that certain conditions would have to be readjusted before the maximum economy could be obtained.

Train Mile Costs Increased

The data obtained during a test period showed, when compared with the operation during a similar period when there were no boosters, that the train-mile costs had increased from $1.409 to $1.456 per train mile. The operation during the period with the increased power required 30,555 train miles to handle 73,432 thousand gross ton-miles, while with the previous operation it had required 39,270 train miles to handle 75,428 thousand gross ton-miles. Thus, while the cost per train mile was increased by 3.3 per cent the unit cost per thousand gross ton-miles for this operation was reduced from 73.4 cents to 60.5 cents, a saving of 12.9 cents per thousand gross ton-miles. This is equivalent to a reduction of 17.6 per cent in the unit costs of operation. The use of this increased power on this subdivision certainly was justified.

These are two examples of how railroads have benefited from an economic study involving the assignment of power, the one obtaining economy through the medium of decreased maintenance expense by employing the use of a different type of locomotive, while the other road found that an increase in the power per locomotive unit made it possible to decrease the direct transportation expense and maintenance expense of the locomotive, when considered on the unit basis of the gross ton-miles handled.

The question naturally arises as to the assignment of locomotives for other types of operation. What about the operation in freight service, which has heavy power assigned to a division, over which it is impossible to utilize over 65 per cent of the power, except occasionally, because of the local conditions and the nature of the business handled? Does the excessive power with the locomotive weights which are involved tend to improve the efficiency and economy of the operation? Would it not have been more economical when this road purchased this power, to have obtained a locomotive with less weight and a less number of drivers, thus obtaining a locomotive which would handle approximately 100 per cent rating, and show an economy in maintenance as against the existing locomotive, especially in view of the fact that because of the physical characteristics of the road, the train load does not materially affect the speed of operation. In a case of description the officers, of course, are counting on the future business, but is it not possible the Old Man Future's stepson, Obsolescence, will run a faster race? It may be possible that when sufficient traffic is available for full train loads, the present locomotive will have become obsolete. The trend in power design during the last few years proves that locomotives built only five years ago have been superseded by later designs which tend to make the older locomotives obsolete. It would therefore appear that a locomotive should be built for today's operation, with a slight margin for the future, but never the margin permitted with 65 per cent of the locomotive rating for the present operation.

Locomotive Service Other Than Freight

So far mention has only been made of freight service, but what about passenger service and service rendered in the yards and terminals? Do these types of service not justify the same study and consideration as freight service?

It would appear that the assignment of the proper type of locomotive which would handle the situation the most economically would be advisable.

On a number of roads increased passenger traffic, together with the steel cars now in use, have in many cases made good locomotives obsolete for main line service because of insufficient power to handle the heavy trains. In these cases it has become necessary to obtain supplemental power in order, in the majority of cases, to start trains properly. The supplemental power, in some cases, was obtained through the medium of an increased number of drivers and increased weight of the locomotive. It would appear that in this case the same as in freight service, through a study of local conditions, it might be possible to obtain an economy because of locomotive design, and let the locomotive booster give the necessary supplemental power rather than increase the number of drivers or weight on drivers.

On many roads today the yard service inherits the locomotives from road service. When more power is needed for yard locomotives the engines assigned, while more powerful and with a greater number of drivers, are usually of an obsolete design for road service and, consequently, no longer prove economical. Therefore, the yard must use these locomotives until such a time as depreciation permits their removal. Is this really in the interest of economy? A desirable yard engine should not only be considered from the angle of the number of cars it will handle, but also from the maintenance standpoint. Would it not be economy in this service to use a specially designed six-wheel switcher, using the booster for the necessary increased power in preference to an eight-wheel switcher or a Consolidation type locomotive inherited from road service?

One road believes that a specially designed switcher for yard service would be the more economical. After a thorough analysis of their local conditions this road decided to employ a six-wheel switcher because of track conditions. With the increased train loads being handled in road service, it was desirable to obtain a switcher locomotive having sufficient power to handle the train units being brought into the terminals with the road engines.

Thus, it was desirable to have an eight-wheel switcher, but track structures making it undesirable, this road considered and finally applied the locomotive booster to the tender of the six-wheel switchers. This gave ample power to handle trains brought into the terminal. It was believed that this method of obtaining increased power would prove the most economical because of the difference in maintenance costs and the possibility of working the locomotive itself to better advantage. The indications are that this yard locomotive is far superior to any other now in use on the road, showing savings in the expense of the locomotive.

Considering all the classes of service, there is one important factor common to all which will have a bearing on the economic situation. This factor is the investment costs. In a study relative to the assignment of locomotives it may be possible that savings may be effected, because of decreased maintenance costs of one type of locomotive in preference to another type of locomotive, or because of the possibility of reducing the unit cost with the use of greater power per locomotive unit. In accomplishing this, however, these savings may be offset because of the investment costs. These carrying charges, or the investment costs, are constant. The investment costs per locomotive mile will depend on the annual mileage made with the particular locomotive.

With a class of business requiring the intensive use of a locomotive for only a short period of time, the investment costs per locomotive mile operated naturally will be excessively high, while on the other hand, locomotives used in constant operation show low investment costs per locomotive mile. Thus, when additional power of locomotives is justified because of the possible decrease in the direct operating expense, it would appear that a study of the investment costs should be made to determine whether new locomotives costing six or eight times the cost of the booster would prove more economical than the existing locomotives equipped with the locomotive booster.

In the assignment of a locomotive to any class of service, there are several outstanding factors that will have a marked bearing on the economics of the operation. With a proper relationship between the traffic and power of locomotives, it is essential that the locomotives giving the required amount of power with the least number of drivers, be used so that a minimum expenditure for maintenance of equipment will be required. A balance between train load and train speed must be obtained so as to obtain an operation giving the greatest production rate with the least unit cost possible. The required power output of the locomotive must be obtained with a minimum of investment costs.

Steam Railway Electrification in 1927

By W. D. Bearce, General Electric Co.

Practically no new electrification projects have been put forward during the year, but a number of the existing electrifications have been extended indicating satisfactory results with electric operation. The Chicago, Milwaukee and St. Paul Railway which has twice previously extended its electric zone, this year completed the electrification of its entrance into Seattle, a 10-mile double-track line from Black River Junction. This extension was placed in service without the addition of substations or locomotive equipment, the only expense being for installation of overhead distribution and bonding.

The Mexican Railway Company has also completed its second extension and is now operating electrically between Esperanza and Paso del Macho, a distance of 62 miles. In this case it was necessary to install a second substation, using two 1500-kw. motor-generator sets to supplement the two 3000-kw. units originally installed in the Maltrata Substation.

The Paulista Railway in Brazil (as noted in the G-E Review for May) has made a fourth extension to its electric zone, bringing the total up to 177 miles. This last extension, which will be in service during the coming year, completes the electrification of the broad gauge lines of this company between Jundishy and Rincao. Any further electrification by this company will probably be accompanied by widening of the present narrow gauge lines. Reports by the officials of this system continue to testify to the savings resulting from electrification. (See G-E Review December.) In this connection it is of interest to note that our International General Electric Company has furnished 24 out of a total of 38 of the locomotives now in service or under construction, six of the eight substations and more than two-thirds of the total mileage of overhead distribution and transmission. There are now under construction at Erie three new passenger locomotives which will shortly be shipped, for taking care of the additional requirements of passenger trains over the new extension.

Equipment for the Anglo-Chilean Consolidated Nitrate Corporation which was shipped early this year including automatic substations, overhead distribution and locomotives, went into service in September. In anticipation of a gradual increase in traffic requirements with electric operation, two additional locomotives are now under construction for this company at our Erie factory.

In the United States perhaps the most interesting work on railroad electrification is that being done by the Great Northern Railway in the state of Washington. Electric operation between Cascade tunnel and Skykomish is to be extended through the new tunnel to Wenatchee before the end of next year. Two motor-generator type locomotives which are the largest single-phase units yet to be built began operation in August, and two more units of the same type now under construction will be shipped during the coming year. These locomotives have functioned most satisfactorily in service. In addition to the locomotives now under construction the equipment for a second frequency changer substation located at Wenatchee is being manufactured. (See G-E Review, October.)

The New York Central Railroad is actively working on the electrification of its west side yards which will be operated from an overhead trolley north of 60th street. Below this point self-propelled, oil, electric and storage battery units will be used, one of which has just been placed in service. This unit is a 120-ton locomotive equipped with a storage battery and 300-h.p. oil-engine generating set for battery charging.

Equipment for the Wilmington division of the Pennsylvania Railroad including 30 single-phase motor car equipments and substation switching equipment, is now being delivered. The switching equipment includes a new type of air circuit breaker with the high-speed characteristics similar to those obtained for direct-current installations. These new breakers have a normal rating of 1,500 amperes and will be used on 11,000-volt, 25-cycle circuits. Oil circuit breakers involving the same operating principle are also to be used. The General Electric Company is also furnishing the electrical equipments for four 200-ton locomotives which will be used on the New York division. The motors for these locomotives are suitable for operation on either alternating or direct current.

A report issued during the year quoting one of the high officials of the Illinois Central Railroad, indicates a usual degree of satisfaction with the equipment furnished for that electrification two years ago. Preliminary figures on net operating income on the suburban service, show an improvement over steam operation of more than $700,000. This improvement is accompanied by an increase in patronage which gives ample justification for the improved service being rendered by the electric operation of this suburban system.

Oil Electric Locomotives

Interest continues in the performance of the oil-electric locomotive, a number of which have now been in service a sufficient period to demonstrate the economies and other operating advantages of this type of motive power. Two 100-ton units are now in heavy switching service on the Erie Railroad and 60-ton units have been delivered during the year to the Chicago and Northwestern Railway, the Union Carbide Company and the American Rolling Mills Company.

Work is proceeding on the oil-electric freight and passenger locomotives for the Putnam division of the New York Central Railroad and the 300-h.p. oil-electric motor car for the same Company is now in service.

Train Communication

Equipment for radio communication between locomotive and caboose or between train and station has been perfected during the year and is giving very satisfactory service on a locomotive operating on the main line fast freight service of the New York Central Railroad. A set has also been developed for use in classification yards for directing the operations of the various engines from the yard director's office.

Interest in electrification abroad continues and one particularly important installation is being made on the Madrid-Paris line of the Spanish Northern Railway. The substation equipment which is being built by our French associates based upon design recommendations by the General Electric Company includes 33,000 kilowatts of synchronous converters, transformers and switching equipment. The protective apparatus of the direct-current circuits will include high-speed circuit breakers. Another installation on the Spanish Northern in the vicinity of Barcelona is using 18,000 kilowatts of similar 1,500-volt d-c. substation units.

As a natural result of its profit-making possibilities, the gas-electric car for branch line and local main line service has continued to show an increased use. Among the more interesting additions to existing equipment are the sixteen cars to be placed in service during the coming year by the Chicago, Burlington & Quincy Railroad, one single unit and two double power plant equipments by the Mobile and Ohio Railroad, ten single unit power plants by the Seaboard Air Line, three dual power plant cars by the New York Central Railroad. The Chicago, Milwaukee and St. Paul Railway is also supplementing its fleet of G. E. gas-electric cars with ten 275-h.p. modern cars. This Company has also replaced the gas engines in one of the older cars with a new generating set consisting of a Foos oil-engine and G. E. generator. The motor and control equipment originally furnished are retained and successful operation is reported. A single unit power plant car has been shipped to the Victorian Railways of Australia for trial on the state lines around Melbourne. Another foreign shipment includes eight cars for the United Railways of Havana. In all, about 60 of these cars have been placed in service during the year.

Self Propelled Locomotives

An interesting application of electric transmission is being made by the Davenport Locomotive Works on industrial type units. These locomotives, weighing from 10 to 30 tons, are using automotive type engine and generating units to secure the flexibility of operation inherent in this type of drive.

A new combination trolley and storage battery type of locomotive is to be used by the Chicago, North Shore and Milwaukee Railroad for yard switching.

Long Runs Reduce Shop Costs

The St. Louis-San Francisco Railroad reduced its roundhouse expenses as a result of the lengthening of passenger and freight locomotive runs for varying distances, from 125 to 500 miles, and the further extension of this practice is expected to bring an additional saving of almost $250,000 a year. These runs, are made from St. Louis, Mo., on Oklahoma City, Okla., 542 miles, and from Kansas City, Mo., to Birmingham, Ala., 635 miles. One test, with a new coal-burning freight locomotive was on a run of 2,940 miles without having the fires dropped. These long runs are eliminating the need for intermediate shop and roundhouse facilities. Forces at the intermediate terminals at Francis, Okla., Afton and Lawton; Newburg, Mo., and Thayer; and Fort Scott, Kans., have been reduced because of lack of work. Other intermediate terminals on the Frisco's various divisions are beginning to experience a reduction of work by reason of the performance of new locomotives with which the road has been replacing older ones and reductions are being made in the shops at Neodesha, Kans., and Chaffee, Mo.

The Relation Between Aviation and the Railroads

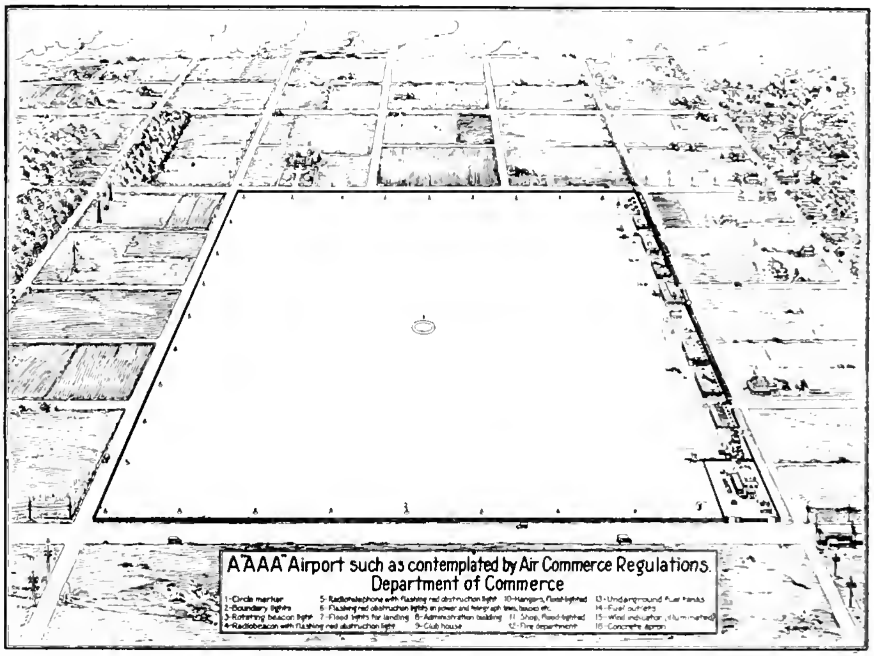
By H. H. Thompson, Aeronautics Engineer, Westinghouse Electric and Manufacturing Company

Much has been said and written about the airport as to its selection and construction. However, there is a great need at the present time for the proper guidance of the various towns and cities of the United States in not only selecting sites but in determining what the prospects of such an airport will be. Major General Mason M. Patrick has issued the first warning in the statement that "smaller communities may become too enthusiastic and try to build too many airports, which when built will be idle." There is no question but what every town and city should provide a place where airplanes may safely land and take off. Certain large cities should provide at least two such places. The extent to which these places should be developed depends to a large extent on the future developments in aviation. What will be the future developments in aviation?

The Post Office Department was the first in this country to see the commercial application of the airplane. It applied the plane to the business of carrying mail. It proved the feasibility of night flying. The experimental period being over, the Post Office Department turned this activity over to private corporations. The next step in the development has been the use of the airplane for carrying express. Certain classes of express such as money, securities and documents, the quick delivery of which is of utmost importance, are now being carried by the airplane. The next step in development is that of passenger carrying. Already there are a few passenger carrying planes operating in various parts of the country. The people are slowly becoming airminded and the use of planes for quick transportation is becoming more and more appreciated. As the passenger traffic increases there will be a demand for larger and larger planes which will carry a greater pay load.

It is quite probable that as soon as the airplane has established itself as a practical and safe means of transportation, the great railroad companies of the United States will immediately become interested and either start competing lines or absorb the new transportation lines, establishing thereby the greatest and quickest form of transportation the world has ever known. Greater advance could no doubt be made if the railroads had an early appreciation of the great possibilities of the airplane and shared in its early development. Assuming that the railroads will some time in the future operate the air transport lines, then the great airports would be operated not by the cities or municipalities but by the railroads. The cost of taking over these lines and airports after the development stage has been completed will be enormous. Would it not, in view of past experience, seem more logical and economical for the railroads to enter this field during the early development? The airports would, under this arrangement, be developed by the railroads along the lines best fitted to meet the needs of transportation. Certain cities, because of their standing as great railroad centers, would become great aviation centers. Following this line of thought, each town and city can judge as to the future of its airport.

On the assumption that the air mail, express and passenger lines of the future are under the control of the railroad companies, it is not difficult to picture the location and general construction of the terminal airports. The airport will be located near or on the main line of the operating railroad company, probably eight or more miles from the heart of the city. An express train will carry passengers, mail and express to and from the airport, from and to the railroad terminal. This airport will not be available for the use of privately owned planes. Elaborate signaling systems will be installed at each of these airports for the control of traffic. The general appearance of the airport will probably be not unlike that described and illustrated by the Department of Commerce as a class AAA Airport, and shown in the illustration.



Diagrammatic View of Recommended Airport

The following cities, because of their present standing as railroad and shipping centers, should therefore locate and set aside one or more sections of ground large enough to qualify in the future as an "AAA" Airport:

Boston
New Haven
New York
Philadelphia
Chicago
St. Paul
Memphis
New Orleans
El Paso
San Francisco

Washington, D. C.
Baltimore
Norfolk
Buffalo
St. Louis
Omaha
Birmingham
Denver
Seattle
Los Angeles

Pittsburgh
Cleveland
Detroit
Cincinnati
Kansas City
Dallas
Atlanta
San Antonio
Portland, Oregon
Salt Lake City

In determining the number of air ports to take care of future transportation requirements, a study should be made of the present railroad requirements, for the handling of traffic between distant cities. Short hauls will still be handled by the railroads while long hauls will be handled by planes supplemented by the railroads.

In addition to the above airports, other airports will be required for local owners of planes and visiting planes. These ports should be laid out to meet the requirements for a Class A airport. It would probably be desirable to locate these ports as near the railroad airport as possible, as in all probability there will spring up taxi-plane service between the city airport and outlying towns.

Every town or city not mentioned above should establish an airport which, as far as area is concerned, should meet the Department of Commerce requirements for Class A rating. The development plan for these ports should be spread out over a period of years rather than over a single year. Each field should be equipped at once with a small office with communication facilities, boundary, approach and obstacle lights, floodlights automatically operated, if the field is unattended, illuminated wind cone and revolving beacon. Other equipment and facilities can be added as the demand for same arises. It might be pointed out that there is a possibility in the future of airplane builders erecting assembly plants at the airports for assembly of planes prior to delivery to customer. Aviation schools will establish themselves at the airports and be a means of securing revenue for maintenance of the port. The number of privately owned planes will increase as the number of places which will enable them to land and take off increases. These will require hangars, the rental of which will also be a source of revenue. Until such time as the airplane design becomes standardized, it is unwise to erect hangars unless there exists a demand for same. A hangar erected today may be too small or of the wrong proportions a year or two from now. Expensive hangars are not justified in the present state of aviation; neither is expensive floodlighting equipment justified unless the air port is extensively used for night flying. The development should allow for easy expansion. The hangars, if erected, should be of such design and construction that alterations can be easily and inexpensively made to meet new conditions. The floodlighting system should be flexible and be capable of expansion at a minimum cost.

In general the demands on a large majority of airports for night flying will be such that it will not be necessary to illuminate the whole field but only that portion of it sufficient for the landing of one plane at a time. It is, however, very important that, regardless of the amount illuminated, the illumination be such that all irregularities of the landing area are shown clearly. A pilot landing on a strange field at night will assume that all shadows cast on the field are ditches or holes, even though the shadows are due to slight irregularities in the field which are not serious for safe landing. The only system of lighting which can be arranged to properly light up an uneven area is the distributed system. This system has another advantage and that is it can be easily increased so as to illuminate more area with minimum cost. Its initial cost is low and has a minimum maintenance cost. It has a distinct advantage over the single source in that the burning out of one lamp will not seriously affect the illumination of the field at a critical time.

The units used in the distributed lighting system lend themselves readily to the changing requirements of an airport. Lamps ranging in watts from 900 to 3,000 can be used without changing any of the mechanism of the projector. A wide or narrow beam can be obtained simply by changing the lens. Where the landing areas or runways are long and narrow and are located near the edge of the airport, projectors having a short throw and wide beam spread should be used. In case the landing area is increased in width at any time the lenses of the projectors may be replaced with ones having a narrower beam spread. The size of the lamp may also be increased to give greater illumination. The cost of such changes is relatively low. The projectors may be arranged in a group to duplicate the lighting effect of a single source with the added advantage previously mentioned that, in case one lamp fails, there is still sufficient illumination by which to land.

The installation at St. Joseph, Mo., consists of five projectors spaced 300 feet apart along one side of the airport. This airport is typical of many airports that will be established all over the country. While there is no night flying carried on at this field, nevertheless the city has seen fit to install the minimum number of floodlights to take care of possible immediate needs. As night flying increases, this airport equipment may be increased at a small additional expense and the present installation may be rearranged to suit new conditions at a very low cost. But one hangar has been erected at this port, half of which is occupied by the National Air Transport Company. This hangar is built of steel frame work and is enclosed with corrugated sheet iron.

The installation at Bettis Field, Pittsburgh, Pa., is an example of the centralized grouping of projectors. Here four projectors are installed to light up that part of the field most used. This is a temporary installation and represents the minimum amount of illumination that should be used. The equipment at this field is used considerably as an aid to the mail plane in landing. Here again is an installation which is capable of expansion at small cost. Probably for some time to come the present installation will take care of the needs of this port. As the field is developed and night flying is increased, other units of the same type will be added to the field and greater area will be illuminated. The lenses will be changed as well as the size of lamps to give a greater throw and consequently illuminate a greater area.

Automotive Transportation and Railroads

The potential carrying capacity of all motor trucks, including those within city limits, is at present but 3.1 per cent of the carrying capacity of railroad cars. The estimated total ton-miles produced by trucks outside of city limits is but 2.1 per cent of the actual production of ton-miles by the railroads.

These are some of the conclusions of a study of relationships now developing between highway and rail transport just made by the Commission on Commerce and Marine of the American Bankers Association.

"While the number of trucks and their transportation product are increasing more rapidly than railroad-produced ton-miles," the Commission reports, "it does not now appear that direct transportation on the rural highways will increase in a degree that will be competitively injurious to railroads. The economic factors place a fairly uniform definite limit on the zones within which the truck can operate economically. . . .

Supplementary Use of Trucks

"Moreover, the railroads themselves are becoming active in utilizing trucks for supplementary service, and where such service in itself is profitable the net income goes to the railroads. . . ."

Discussing the economic limits of the truck, the Commission refers to its report of last year when it found that the truck haul of 50 to 60 miles was the normal outside limit, and that the typical truck haul was from 25 to 30 miles.

Both Means Have Advantages

"It is, of course, unsafe here to generalize," the report continues, "as the economic limit depends in part upon the commodity and the local conditions, including the character and adequacy of railroad service, and what rates the traffic will bear. Motor truck service appeals to shippers who value the elements of direct collection and delivery, speed and flexibility, savings in containers, and the lessening of risk of damage and theft of fragile, perishable or high value commodities. These advantages may outweigh the desirability of the lower rate by rail. But where such advantages are slight and where the distance is such as to enable the railroad to serve at lower cost, the shipper is likely to favor the railroad if its service is reasonably adequate. . . .

One Train Equals 154 Trucks

"It is easy to see why the trucks cannot successfully compete with railroads for mass movements of freight outside of terminal districts. The average freight train in 1926 carried 772 tons of freight. To carry that train load in motor trucks of 5 tons capacity, fully loaded, would require 154 trucks and at least 154 truck drivers.

"The freight train normally has a crew of 5 to 6 men. For each man on the freight train there were 128 to 154 tons; for each truck driver there would be but 5 tons. The fuel consumed by the freight train was about 300 pounds per train-mile and the cost at $4 per ton was 60 cents. For the 154 trucks, the total gasoline consumption would be at least 40 gallons per mile and the cost at 18 cents per gallon would be $7.20. If the fleet of trucks were spaced a truck length apart they would occupy more than one mile of highway.

"This comparison, impressive as it is, does not entirely reflect the facts, as the average train load just given is for trains in both directions—heavy traffic and light traffic—while for truck operation a full load is assumed for each truck. In the heavy traffic direction alone the average freight train has at least 1,200 tons of freight. That load would require the use of 240 five-ton trucks and the same number of truck drivers."

Consumption of Fuel Oil Decreases

Increased prices of fuel oil, especially in the South Central States, and increased efficiency in its utilization, especially in California, Texas, and Louisiana, caused a slight decrease in consumption by the railroads of the country in 1926, as compared with 1925, it is stated in a report just made by the Bureau of Mines of the Department of Commerce.

Although the general consumption of fuel of all kinds by Class I railroads increased 0.53 per cent in 1926 over 1925, the quantity of fuel oil consumed by locomotives on Class I railroads decreased 0.33 per cent, and the fuel oil consumed by all railroads for which information is available decreased 0.9 per cent, from 69,461,119 barrels in 1925 to 68,836,850 barrels in 1926.

The principal decreases took place in the California district; in the South Central district; and in the Atlantic district. Railroad fuel oil consumption increased slightly in the Oregon-Washington district, and to an unimportant extent in the Rock Mountain district.

Railroads Increase Stocks

During 1926, a total of 71,446,956 barrels of fuel oil was purchased by the 152 Class I, II, and III railroads included in the Bureau of Mines compilation. Of the total amount purchased, 68,836,850 barrels were consumed, and 2,610,106 barrels added to the quantity in storage. Railroad stocks of fuel oil at the end of 1926 amounted to 16,541,845 barrels, as compared with 13,931,739 barrels at the beginning of the year. Of the total, 59,329,690 barrels was burned as locomotive fuel, and 9,507,160 barrels was consumed in shops, power plants, ferry boats, and other uses than for firing locomotives.

"As in 1925 more than four-fifths of the oil burned by railroads in the United States was consumed in the South Central States and in California. Railroads operating in these two regions consumed 56,458,246 barrels, or 82 per cent of the 1926 total. A little over eight per cent was consumed in Oregon and Washington, and a little over six per cent in the South Atlantic region. The remaining four per cent was consumed in the North Central States and in the area adjacent to the Wyoming and Montana oil fields.

No Definite Trend Indicated

From 15,577,670 barrels in 1906 the consumption of oil as a locomotive fuel has grown more than fourfold in 20 years.

No uniform national tendency, either toward the conversion of the coal burning locomotives to oil burning or the reverse, can be deduced. The quantity of fuel oil used each year varies in each region with the relative costs of oil and coal, the volume of traffic, the adoption of oil burning by railroads previously burning coal or the reverse, and the efficiency of burning.

Motive Power Condition

Locomotives in need of repair on the Class I railroads of this country on November 15 totaled 9,289 or 15.3 per cent of the number on line, according to reports just filed by the carriers with the Car Service Division of the American Railway Association.

This was an increase of 511 locomotives compared with the number in need of such repairs on November 1, at which time there were 8,778 or 14.4 per cent.

5,812 Locomotives Above Needs

Locomotives in need of classified repairs on November 15 amounted to 4,915 or 8.1 per cent, an increase of 271 compared with November 1, while 4,374 or 7.2 per cent were in need of running repairs, an increase of 240 compared with the number in need of such repairs on November 1.

Class I railroads on November 15 had 5,812 serviceable locomotives in storage compared with 5,520 on November 1.

Freight Cars Needing Repair

Freight cars in need of repair on November 15 totaled 137,374 or 6 per cent of the number on line, according to reports filed by the carriers with the Car Service Division of the American Railway Association.

This was a decrease of 2,067 ares under the number reported on November 1, at which time there were 139,441 or 6.1 per cent. It also was a decrease of 2,110 cars compared with the same date last year.

Freight cars in need of heavy repair on November 15 totaled 100,347 or 4.4 per cent, a decrease of 389 compared with November 1, while freight cars in need of light repair totaled 37,027 or 1.6 per cent, a decrease of 1,678 compared with November 1.

Equipment Installed in First 11 Months

Freight cars placed in service the first eleven months of 1927 by the Class I railroads totaled 72,228, according to reports filed by the rail carriers with the Car Service Division of the American Railway Association.

This was a decrease of 27,137 compared with the number placed in service in the corresponding period of 1926.

Of the total number placed in service in the first eleven months of 1927, the railroads installed 5,864 freight cars in the month of November, which included 2,000 box cars, 3,292 coal cars and 109 refrigerator cars.

The railroads on December 1, 1927, had 9,850 freight cars on order compared with 14,564 on the same date in 1926.

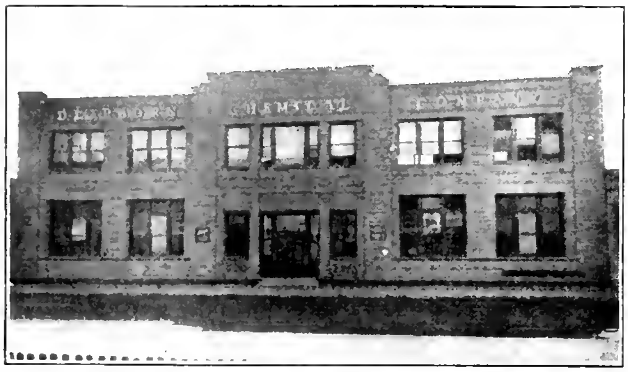
Locomotives placed in service in the first eleven months of 1927 totaled 1,820 of which 149 were installed in November. In the first eleven months of 1926, the railroads placed in service 2,193 locomotives. Locomotives on order on December 1, 1927, numbered 69 compared with 344 on December 1, 1926.

Dearborn Chemical Company's New Warehouse

The new warehouse, plant, and offices of the Dearborn Chemical Company in Los Angeles, California, are located at 807 to 815 Mateo Street.

Ground space 100 x 140 feet was purchased and a building 57 x 115 feet constructed in the summer of 1927. The building, of brick and concrete, contains nearly 13,000 feet of floor space. The remainder of the ground area is used for oil tank storage. Seven 10,000 gallon tanks are already installed.

The plant is equipped with several blending tanks, for the compounding of oils for individual lubrication requirements, together with machinery and equipment necessary for the manufacture and storage of other products manufactured by the Company, chief of which are Dearborn Scientific Water Treating Preparations and NO-OX-ID Rust Preventive.



Dearborn Chemical Company Warehouse at Los Angeles, Calif.

The property is served by a private switch operated by the Southern Pacific Railway.

This extension of manufacturing facilities relieves the congestion in the main plant at Chicago, and better serves the Company's clientele on the Pacific Coast, and in the Hawaiian Islands.

The Pacific Coast business of the Company is managed by Mr. Alex B. Burns.

Notes on Domestic Railroads

Locomotives

The Great Northern Railway is building four locomotives in its shops at Hillyard, Wash.

The Southern Railway has ordered 55 Mikado type locomotives, 5 Pacific type locomotives and 8 Mallet type locomotives, from the Baldwin Locomotive Works.

The Texas & Pacific Railway has ordered 16 2-10-4 type locomotives from the Lima Locomotive Works.

The Midland Valley Railway is inquiring for 4 locomotive tenders.

The Mobile & Ohio Railroad is in the market for eight switching locomotives.

The Clemons Logging Company has ordered one 2-6-6-2 Mallet type locomotive, from the Baldwin Locomotive Works.

The Reading has ordered a 60-ton oil electric locomotive from the Ingersoll-Rand Company, the General Electric Company, and the American Locomotive Company, which companies co-operate in its manufacture.

The Boston & Maine Railroad has ordered 20 2-8-4 type locomotives, from the Lima Locomotive Works.

The Japanese Government Railways has ordered a 1200 h.p. Diesel locomotive, direct drive, from the Friedrich Krupp A. G., Germany.

The Chesapeake & Ohio Railway has given a contract for the repair of 12 class H-4 Mallet type locomotives, to the Newport Shipbuilding & Dry Dock Company. The work is to be done at an approximate cost of $300,000 in the Shipbuilding Company's shop at Newport News.

The Seaboard Air Line is inquiring for 25 switching locomotives.

The Alabama, Tennessee & Northern Railroad has ordered 2 Decapod type locomotives from the Baldwin Locomotive Works. Inquiry for 3 locomotives was reported in the Railway Age of August 27.

Freight Cars

The Chicago & North Western Railway has ordered 250 hopper car bodies from the Standard Steel Car Company and 250 from the Illinois Car & Manufacturing Company, and 25 caboose cars from the American Car & Foundry Company.

The Lehigh & New England Railroad has been getting prices on six caboose cars.

H. C. Frick Coke Co. plans to have 640 coke cars repaired under contract.

The Argentine State Railways is inquiring for about 700 cars to include box, flat and tank cars.

The Atlantic Coast Line has been getting prices on 75 steel underframes for box cars.

Wilson & Co., packers, have been in the market for 300 refrigerator cars of 40-ton capacity.

The Atchison, Topeka & Santa Fe Railway has ordered 750 stock cars from the Pennsylvania Tank Car Company, 500 gondola cars and 300 flat cars from the American Car & Foundry Company, 500 refrigerator cars and 500 box cars from the Pullman Car and Manufacturing Corporation, 500 automobile cars from the General American Car Company, 500 box cars from the Mount Vernon Car Manufacturing Company and 100 ballast cars from the Rodger Ballast Car Company.

The Fruit Growers Express has ordered 240 steel underframes from the Pressed Steel Car Company, and 60 from the Pennsylvania Car Company.

The Pacific Fruit Express has made inquiries for prices on from 300 to 600 steel underframes.

The Chicago, St. Paul, Minneapolis & Omaha Railway has ordered 250 gondola cars from the Standard Steel Car Company.

The United States Navy, Bureau of Aeronautics, is inquiring for tank cars to carry Helium gas.

The Mobile & Ohio Railroad is in the market for 200 flat cars, 250 gondolas and 250 box cars.

The Chicago & Eastern Illinois Railway is inquiring for 500 automobile box cars of 40 tons' capacity.

The Bangor & Aroostook Railroad is in the market for 100 box cars.

The Andes Copper Mining Co. is in the market for 20 cathode cars.

The Gulf, Mobile & Northern Railroad has ordered 12 center hinge air dump cars of 30 cu. yd. capacity, from the Koppel Industrial Car & Equipment Company.

The St. Louis-San Francisco Railway is inquiring for 500 flat cars of 55 tons' capacity, 1,500 box cars and 500 automobile box cars of 50 tons' capacity and 1,500 hopper cars of 70 tons' capacity.

The H. C. Frick Coke Company is inquiring for prices on the repair of 640 coke cars of 70 tons' capacity.

The Southern Railway has ordered 200 hopper cars from the Standard Steel Car Company, 750 hopper cars from the Mount Vernon Car Manufacturing Company, 1,750 automobile box cars from the American Car & Foundry Company and 250 ballast.

The Woodward Iron Company is inquiring for 10 steel ore cars of 60 tons' capacity.

The Swift Company is inquiring for 300 steel underframes for refrigerator cars

Passenger Cars

The Havana Central Railway is inquiring for 9 interurban motor cars, 39 feet long.

The Nashville, Chattanooga & St. Louis Railway is inquiring for two combination baggage and passenger cars, and two baggage cars.

The Louisville & Nashville Railroad has ordered 2 baggage cars, 2 combination passenger and baggage cars, 4 middle smoking compartment coaches, 4 coaches, all 70 ft. long and 4 combination passenger and baggage cars 61 ft. 2 in. long, from the American Car & Foundry Company.

The Southern Railway has ordered 23 combination mail and baggage cars and 2 full postal cars from the Bethlehem Steel Company.

The Illinois Central Railroad will issue an inquiry soon for 20 suburban coaches.

The New York, Westchester & Boston Railway has ordered 16 motor passenger train cars from the Osgood Bradley Car Company.

The Baltimore & Ohio Railroad has ordered 11 passenger gas-electric rail motor cars and 1 passenger, baggage and mail gas-electric rail motor, all 60 ft. long and 1 50-ft. 10-in. passenger trailer car, from the J. G. Beill Company.

The Chicago & North Western Railway has ordered 5 gas-electric rail motor cars from the Pullman Car & Manufacturing Corporation.

Supply Trade Notes

Hendrick Manufacturing Company, Carbondale, Penna., manufacturers of Mitco Interlocked Steel Grating, Mitco Shur-Site Stair Treads and Mitco Armorgrids, announces the opening of a Chicago District Office, 223 Railway Exchange Building, Chicago, in charge of Mr. Lon Sloan. Mr. Sloan's extensive floor grating experience is available to those concerned with the selection of floor grating, stair treads and armorgrids for reinforcing concrete floors, platforms and driveways.

William H. Woodin, chairman of the board of the **American Locomotive Company,** has been elected president also, to succeed Frederick F. Fitzpatrick, deceased. Mr. Woodin was first elected president of the American Locomotive Company in December, 1925, succeeding Andrew Fletcher, deceased. When the Railway Steel-Spring Company was amalgamated with the American Locomotive Company in 1926, Mr. Woodin was made chairman of the board of the American Locomotive Company, and Frederick F. Fitzpatrick, who had served as president of the Railway Steel-Spring Company since 1910, was made president. Mr. Woodin now combines the offices of chairman of the board and president. He is also president of the **American Car & Foundry Company.**

The general offices and factory of the **Railway Curtain Company** are now located in the company's new building, 3352 West Grand avenue, Chicago.

George B. Wood, Philadelphia, Pa., is manager of railway sales of the **Goodall Rubber Company, Inc.,** and **Charles L. Butler,** who formerly represented the **Detroit Lubricator Company,** has been appointed manager of railway sales in the Chicago district with headquarters at Chicago.

The Southwark Foundry & Machine Company, Philadelphia, Pa., jointly with the **Emery-Tatnail Company,** have established a testing equipment division and are offering a diversified line of physical testing machines and instruments of high quality.

L. M. Ritchie has been appointed district manager, railway sales of the **E. I. Du Pont de Nemours Company, Inc.,** with headquarters at Chicago.

C. J. Buck has been appointed service manager of the **Franklin Railway Supply Company, Inc.,** New York, succeeding John L. Bacon, who has resigned to enter business for himself.

The Bradford Corporation, New York, will in future handle the business of the **Walker Draft Gear Company,** and **Edmund H. Walker,** heretofore president of the latter company, has been appointed a vice-president of the Bradford Corporation, with headquarters at New York.

W. J. Walsh, vice-president of the **Galena Signal Oil Company** with headquarters at Chicago, has resigned to become president of the **Transportation Service Corporation,** Chicago.

Charles W. Bell, formerly of the **Edison Storage Battery Company,** has been appointed general sales manager of the **Gould Storage Battery Company, Inc.,** with headquarters at Depew, N. Y. **L. C. Hensel,** formerly of the **Gould Car Lighting Corporation,** has been appointed manager of railway sales, with headquarters at New York.

The B. & S. Manufacturing Corporation, Hoboken, N. J., has appointed the **T-Z Railway Equipment Company, 14 E.** Jackson Boulevard, Chicago, its western sales representative.

The Ohio Brass Company, Mansfield, Ohio, will create an executive branch in New York January 1 to cover New England and the territories served by its New York and Philadelphia sales offices, and thereby improve its service in that part of the country. **Frederick Attwood,** who will be in charge, directed the interests of the Ohio Brass Company in Europe for several years, and has returned to this country to undertake the organization and direction of the New York executive office.

The Eppinger & Russell Company has removed its main office from 165 Broadway to the Park-Murray building, 11 Park place, New York City.

H. W. Kilkenny, representative of the **Ohio Brass Company,** Mansfield, Ohio, for the past four years, with headquarters in the Pittsburgh district, has been transferred to the St. Louis district. **S. W. Walworth** succeeds Mr. Kilkenny in the Pittsburgh territory. Mr. Walworth previously served for three years with the **Pittsburgh Transformer Company** in a sales capacity in the Pittsburgh territory.

The Pillod Company, with officers at New York City and Chicago, manufacturers of the Baker, Southern and Young valve gears, have acquired the exclusive sales and service of the locomotive cut-off control manufactured by the **Transportation Devices Corporation,** Indianapolis, Ind.

Joseph A. Donahey, sales and service engineer of the **Cleveland Frog & Crossing Co.,** Cleveland, Ohio, has been appointed manager of sales, succeeding George Stanton, deceased.

The directors of both the **Republic & Steel Co.,** and the **Trumbull Steel Company** have approved a plan for the consolidation of these companies. The plan will be submitted to the stockholders of both companies for ratification.

George A. Price, secretary and treasurer of the **American Arch Company, Inc.,** New York City, was elected executive vice-president on November 28.

G. W. Brogan, Inc., Towson, Maryland, advertising counsel, announce that their organization has been augmented by the addition of **R. M. Welch,** automotive service and tool expert.

Van Cortright Mekeel, formerly connected with **Taylor-Wharton Iron & Steel Co.** of High Bridge, N. J., in capacities of special research investigator, mechanical engineer and sales engineer, has resigned to accept a post as special representative of **The Nugent Steel Castings Co.,** Chicago, Illinois.

Items of Personal Interest

E. P. Marsh, superintendent of car shops of the Chicago & North Western Railway, with headquarters at Chicago, has been promoted to assistant superintendent of the car department, assigned to special duties and with headquarters at Chicago. **George E. Collins,** assistant superintendent of car shops, with headquarters at Chicago, has been promoted to superintendent of car shops replacing Mr. Marsh.

A. P. Prendergast, mechanical superintendent of the Texas & Pacific Railway, has his jurisdiction extended also over all allied lines, recently acquired by that system.

B. E. Madden has been appointed roundhouse foreman of the Missouri Pacific Railroad at Atchison, Kan., and **D. M. Ferry** becomes night roundhouse foreman at Falls City, Neb.

Clarence H. Norton, master mechanic of the Susquehanna, Allegheny, Tioga and Bradford divisions of the Erie Railroad with headquarters at Hornell, N. Y., has been appointed shop superintendent, with same headquarters, succeeding **Albert J. Davis,** resigned. Mr. Norton will be succeeded by **Charles J. Gerbes** as master mechanic at Hornell.

S. W. Fisher has been engaged to make a special study of economics of transportation matters on the National Railways of Mexico.

C. R. Coen has been appointed roundhouse foreman of the Missouri Pacific Railroad, at North Pleasanton, Tex.

Frank W. Johnson has been appointed traveling engineer of the Minneapolis, St Paul & Sault Ste. Marie Railway, with headquarters at Minneapolis, Minn., succeeding Grant W. Stanton, transferred. **Milo P. Lybeck,** assistant fuel supervisor, with headquarters at Enderlin, N. D., has been appointed traveling engineer of the Stevens Point Division, with headquarters at Stevens Point, Wis., succeeding **Charles F. Gillaspy,** resigned.

H. W. Ostrom, chief chemist of Chicago, Milwaukee & St Paul Railway, with headquarters at Milwaukee, Wis., has resigned to become connected with the Aluminum Company of America at Chicago.

M. E. Hamilton has been appointed general air brake instructor of the Denver & Salt Lake Railroad with headquarters at Utah Junction, Colo.

Alfred G. Hoppe, assistant engineer of tests of the Chicago, Milwaukee & St. Paul Railway, has been appointed engineer of tests, with headquarters at Milwaukee, Wis.

John H. Minette, assistant general foreman at the West Springfield shops of the Boston & Albany Railroad, has been appointed general foreman of the locomotive shops at West Springfield, Mass., succeeding **Joseph W. Murphy**, deceased.

J. O. Green has been appointed master mechanic of the Mississippi Central Railroad, with headquarters at Hattiesburg, Miss.

Obituary

F. F. Fitzpatrick, President of the American Locomotive Company and Chairman of the Board of Directors of the Railway Steel-Spring Company, died from heart disease at his home at Larchmont, N. Y., on November 16th. Mr. Fitzpatrick was born in Canada on June 9th, 1866. He received his education at Chillicothe, Mo., and began his career on the Missouri Pacific Railroad, his first position being telegraph operator. In railroad service he received rapid promotion, and in 1899 decided to enter the railway supply trade, beginning with the Scott Spring Company, which afterwards became a component of the Railway Steel-Spring Company. It was in 1910 that he was elected President of this Company, and later, upon the affiliation formed with the American Locomotive Company, he became Chairman of the Board of the former and President of the latter.

Daniel J. Redding, who was formerly superintendent of motive power of the Pittsburgh & Lake Erie Railroad died at his home at Dormont, Pa., on December 8th.

New Publications

Books, Bulletins, Catalogues, Etc.

American Society for Testing Materials 1927 Book of Standards. The Standards appear in two parts. Part I deals with Metals and Part II Non-Metallic Materials.

Part I contains 144 standards relating to metals and Part II 1926 relating to non-metals. The two parts contain respectively 871 and 1000 pages; and the total of nearly 1900 pages is over 50 per cent larger than the previous 1924 edition.

Some new features of the books designed to facilitate their use and enable the reader more quickly to locate a given standard either by title or subject matter deserve particular mention. The index to each part is more complete than ever before and has been improved in arrangement. A new feature that we believe will be most helpful is the use of bold face type for the significant subject words in the titles of the specifications and methods of test indexed. The omission of such words as "methods of" in the titles and the abbreviation of "specifications" and "definitions" serves to condense the references and speed up the use of the index. Improvements have been made in the arrangement of the two tables of contents, one table listing the standards according to subjects and the other in numeric sequence of their serial designation. A guide to the use of the Book of Standards is introduced for the first time on page 4 of each part and will undoubtedly be a help to the user of the books.

A new cloth binding has been used that is at once more attractive and more serviceable than the one formerly used. It has been adopted for the cloth binding of all the Society's publications.

Proceedings of the Nineteenth Annual Convention of the International Railway Fuel Association, 1927. The volume contains four hundred and seventy-six pages and contains the usual comprehensive reports on all sorts of fuel subjects and a number of papers and addresses chiefly on operating factors of fuel economy and the relation of the railways to the mining industry.

Mechanical Application and Novelties of Construction, by Gardner D. Hiscox, M. E. An illustrated work of 412 pages, published by The Norman W. Henley Publishing Company, New York City. The present volume supplements an earlier work, entitled Mechanical Movements, and will no doubt be found a valuable companion to the earlier book. There are chapters on the mechanical power lever, the transmission of power, the generation of power, air-power motors and appliances, hydraulic power and appliances, electric power and devices, gearing and great motion mining devices and appliances, and radio telegraphy and telephony.

Boiler Makers' Tools is the title of an illustrated booklet being sent out by the J. Faessler Mfg. Co., Moberly, Mo. This firm has been making tools for boiler makers for nearly 30 years, and have been supplying the trade in this and foreign countries.

Metal Statistics 1927. A book of 544 pages, published by the American Metal Market, New York City. This is the 20th annual edition of Metal Statistics; and, agreeably to the continual aim of the publishers, an effort has been made to furnish statistics that provide the information most generally required by producers and consumers, and by buyers and sellers of metals. The work has a broad and well-defined field of usefulness.